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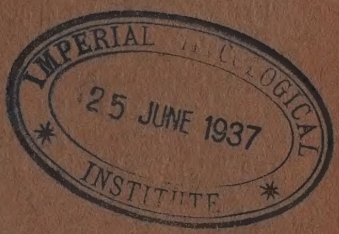

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COMPTES RENDUS

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MATHËMATIK

ZUR LAPLACE-TRANSFORMATION. VII

Von V. S. IGNATOVSKIJ (W. IGNATOWSKY), korrespondierendem Mitglied der Akademie

In der vorhergehenden Note VI (1) nehmen wir an

$$\Phi(x, y, t) = f(x, y) = F(x, y) = 0 \tag{1}$$

und

$$\mu = \nu = m = 0 \tag{2}$$

und erhalten dann statt (1) Note VI die gewöhnliche zweidimensionale Wellengleichung

$$\frac{1}{c^2}\frac{\partial^2 u}{\partial t^2} - \frac{\partial^2 u}{\partial x^2} - \frac{\partial^2 u}{\partial y^2} = 0. \tag{3}$$

Als Randbedingung setzen wir jetzt:

$$u_0(y, t) = \sin \omega t \cdot \psi(y); \quad t \geqslant 0 \tag{4}$$

mit $\omega = \frac{2\pi}{T}$ und

$$\psi(y) = \begin{cases} 0; & |y| > a, \\ 1; & |y| < a, \end{cases} \tag{5}$$

d. h. wir haben einen Spalt der Breite $2a$.

Laut (14) Note VI wird jetzt die Lösung des Problems sein:

$$u(x, y, t) = -\frac{c}{\pi}\frac{\partial}{\partial x}\int_{\frac{x}{c}}^{t} \sin \omega (t - z)\, dz \int_{-\sqrt{c^2 z^2 - x^2}}^{\sqrt{c^2 z^2 - x^2}} \frac{\psi(y - s)\, ds}{\sqrt{c^2 z^2 - x^2 - s^2}}; \quad tc > x, \tag{6}$$

und ist gleich Null für $tc < x$.

Unter Beachtung, dass wir statt (5)

$$\psi(y) = \frac{2}{\pi}\int_0^{\infty} \frac{\sin at \cdot \cos ty}{t}\, dt = \begin{cases} 0; & |y| > a, \\ 1; & |y| < a, \end{cases} \tag{7}$$

setzen können, erhalten wir aus (6)

$$u(x, y, t) = -\frac{2c}{\pi}\frac{\partial}{\partial x}\int_{\frac{x}{c}}^{t}\sin\omega(t-z)\,dz\int_{0}^{\infty}\frac{\sin cs\cdot\cos ys}{s}\cdot J_0(s\sqrt{c^2z^2-x^2})\,ds. \quad (8)$$

Wir führen nun folgende Funktion ein:

$$A(x, y) = \int_{x}^{\infty} e^{-i\omega\tau}\,dz\int_{0}^{\infty}\frac{\sin sa\cdot\cos sy}{s}\cdot J_0(s\sqrt{c^2z^2-x^2})\,ds =$$

$$= \frac{1}{c}\int_{0}^{\infty}\frac{\sin sa\cdot\cos sy}{s\sqrt{s^2-k^2}}\,e^{-x\sqrt{s^2-k^2}}\,ds;\quad k=\frac{\omega}{c}, \quad (9)$$

oder

$$A(x, y) = -\frac{1}{c}\sqrt{\frac{\pi i}{2k}}\,\Phi_{1/2,\,0}(x, y) =$$

$$= \frac{1}{c}\sqrt{\frac{\pi a}{2k}}\left\{\int_{1}^{\infty}\frac{e^{-xk\sqrt{s^2-1}}\cos(sky)\cdot J_{1/2}(kas)\,ds}{\sqrt{s}\sqrt{s^2-1}} - \right.$$

$$\left. - i\int_{0}^{1}\frac{e^{-ikx\sqrt{1-s^2}}\cos(sky)\cdot J_{1/2}(kas)\,ds}{\sqrt{s}\sqrt{1-s^2}}\right\}. \quad (10)$$

Bezeichnen wir, wie gewöhnlich, $Im\{z\} = y$, in $z = x + iy$, so wird demnach sein

$$u(x, y, t) = \sqrt{\frac{2a}{k\pi}}\,\frac{\partial}{\partial x}\left[Im\left\{e^{i\omega t}\Phi_{1/2,\,0}\right\}\right] + M(x, y, t), \quad (11)$$

wobei

$$M(x, y, t) = \frac{2c}{\pi}\frac{\partial}{\partial x}\int_{t}^{\infty}\sin\omega(t-z)\,dz\int_{0}^{\infty}\frac{\sin sx\cdot\cos sy}{s}\cdot J_0(s\sqrt{c^2z^2-x^2})\,ds \quad (12)$$

bedeutet.

Die Funktion $\Phi_{1/2,\,0}$ ist schon früher von mir bei anderer Gelegenheit ausführlich untersucht worden (²) (Seite 27 u. flg.) und zwar wird sein:

$$\sqrt{\frac{2a}{k\pi}}\left(\frac{d\Phi_{1/2,\,0}}{\partial x}\right)_{x=0} = \begin{cases} 1; & |y| < a, \\ 0; & |y| > a. \end{cases} \quad (13)$$

Bezeichnen wir ferner durch r die Entfernung vom Koordinatenanfang bis zum Aufpunkt und $\frac{y}{r} = \sin\vartheta$, so haben wir für grosse r, oder genauer bei $\frac{kr^2}{2\pi r} \ll 1$:

$$\Phi_{1/2,\,0} = \sqrt{\frac{a}{r}}\,e^{-ikr-\frac{i\pi}{4}}\,\frac{\sin(ka\sin\vartheta)}{ka\sin\vartheta}. \quad (14)$$

Endlich genügt $\Phi_{1/2,\,0}$ der Gleichung

$$k^2u + \frac{\partial^2u}{\partial x^2} + \frac{\partial^2u}{\partial y^2} = 0. \quad (15)$$

Beachten wir nun, dass für grosse t

$$M(x, y, t) = -\frac{2xa}{\pi\omega c^2 t^3}, \quad t \to \infty, \tag{16}$$

so können wir auf Grund der erhaltenen Resultate folgende wichtige Schlüsse ziehen.

Wegen (16) erhalten wir aus (11):

$$u(x, y, t) = \sqrt{\frac{2a}{k\pi}} \frac{\partial}{\partial x}\left[Im\left\{e^{i\omega t}\Phi_{1/2,\,0}\right\}\right]; \quad t = \infty. \tag{17}$$

Wir sind also von der Lösung (5), welche der hyperbolischen Gleichung (3) genügt, zu der Lösung (18) der elliptischen Gleichung (15) übergegangen.

Wir sind von einem Anfangszustand mit Randbedingungen zu einem stationären Zustand und zwar, wegen (13), mit denselben Randbedingungen gekommen. Ausserdem wird, wie aus (14) ersichtlich, der Bedingung einer ausstrahlenden Welle, für grosse r, genügt.

Augenscheinlich ist dieser Übergang zu dem stationären Zustand nicht durch irgendwelche Dämpfung bedingt, da wir ja $\mu = \nu = m = 0$ angenommen haben, sondern anscheinend dadurch, dass bei genügend grossem t der Wellenkreis, bei der angenommenen Ranbedingung, solche Teile der Grenzlinie bestreicht, wo $u_0(y, t) = 0$ sein wird.

Es ist nun klar, dass die Möglichkeit eines solchen Überganges nur dann gegeben sein wird, wenn die eingeprägte Grösse $u_0(y, t)$, für $t > 0$, selbst einen stationären Charackter aufweist.

Stellt im speziellen $u(x, y, t)$ die elektrische Kraft parallel der Z-Achse dar, so können wir, indem wir unsere Grenzfläche (mit Ausnahme des Spaltes) durch einen absolut reflektierenden Schirm ersetzen, die erste Randbedingung in (5) erzwingen; die zweite aber nicht, denn innerhalb des Spaltes, bei Annäherung an den Rand, muss die elektrische Kraft zu Null streben.

Wir wollen hier nicht näher darauf eingehen und verweisen nur noch auf unsere frühere Arbeit [3], wo ebenfalls die Funktion $\Phi_{1/2,\,0}$ untersucht und auch angewandt worden ist.

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[1] V. Ignatovskij, C. R. Acad. Sci. URSS, XV, № 2 (1937). [2] V. Ignatovskij, Untersuchungen einiger Integrale mit Besselschen Funktionen und ihre Anwendung auf Beugungserscheinungen und andere. Teil I. Untersuchung der Integrale, Acad. Sci. URSS. Inst. Steklow, III_1 (1933). [3] V. Ignatovskij, Ann. d. Physik, IV. Folge, 77, 589 (1925).

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MATHÉMATIQUES

SUR LA POSSIBILITÉ D'ADJOINDRE A UN SYSTÈME COMPLET D'ÉQUATIONS NON LINÉAIRES UNE ÉQUATION LINÉAIRE, UN SYSTÈME D'ÉQUATIONS LINÉAIRES

Par G. V. PFEIFFER, de l'Académie Ukranienne

Prenons un système complet d'équations non linéaires sous la forme:

$$\left.\begin{aligned} &p_1 - \Phi_1(x_1, \ldots, x_m, x_{m+1}, \ldots, x_{m+n}, p_{m+1}, \ldots, p_{m+n}) = 0, \\ &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ &p_m - \Phi_m(x_1, \ldots, x_m, x_{m+1}, \ldots, x_{m+n}, p_{m+1}, \ldots, p_{m+n}) = 0. \end{aligned}\right\} \quad (1)$$

Ayant ajouté la relation

$$p_{m+1} - \varphi_2 p_{m+2} - \varphi_3 p_{m+3} - \ldots - \varphi_n p_{m+n} - \varphi_1 = 0, \quad (2)$$

exigeons que le système (1), (2) soit complet.

On obtient les équations:

$$\sum_{\rho=2}^{n} \frac{\partial \varphi_\rho}{\partial x_\nu} p_{m+\rho} + \frac{\partial \varphi_1}{\partial x_\nu} - \frac{\partial \Phi_\nu}{\partial x_{m+1}} - \frac{\partial \Phi_\nu}{\partial p_{m+1}} \left(\sum_{\rho=2}^{n} \frac{\partial \varphi_\rho}{\partial x_{m+1}} p_{m+\rho} + \frac{\partial \varphi_1}{\partial x_{m+1}} \right) =$$

$$= \sum_{j=2}^{n} \left[\frac{\partial \Phi_\nu}{\partial p_{m+j}} \left(\sum_{\rho=2}^{n} \frac{\partial \varphi_\rho}{\partial x_{m+j}} p_{m+\rho} + \frac{\partial \varphi_1}{\partial x_{m+j}} \right) - \frac{\partial \Phi_\nu}{\partial x_{m+j}} \varphi_j \right], \quad (3)$$

$$\nu = 1, 2, \ldots, m,$$

$$p_{m+1} = \sum_{\rho=2}^{n} \varphi_\rho p_{m+\rho} + \varphi_1. \quad (4)$$

Il est nécessaire que les égalités (3) deviennent des identités quand on fait la substitution (4).

De là un système d'équations linéaires aux derivées partielles du premier ordre à plusieurs fonctions inconnues

$$\varphi_1, \varphi_2, \ldots, \varphi_n. \quad (5)$$

Si ce dernier système admet une solution, on peut adjoindre au système (1) l'équation linéaire (2).

Cas particulier. Quand le système (1) est un système d'équations linéaires homogènes:

$$\left.\begin{aligned} &X_1(z) = p_1 + b_1' p_{m+1} + b_2' p_{m+2} + \ldots + b_n' p_{m+n} = 0, \\ &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ &X_m(z) = p_m + b_1^m p_{m+1} + b_2^m p_{m+2} + \ldots + b_n^m p_{m+n} = 0, \end{aligned}\right\} \quad (6)$$

on peut lui adjoindre l'équation

$$p_{m+1} - \varphi_2 p_{m+2} - \varphi_3 p_{m+3} - \ldots - \varphi_n p_n = 0\ (1). \tag{7}$$

Ayant ajouté au système (1) les relations

$$\left.\begin{aligned} p_{m+1} - \xi_3 p_{m+3} - \ldots - \xi_n p_{m+n} - \xi_0 &= 0, \\ p_{m+2} - \eta_3 p_{m+3} - \ldots - \eta_n p_{m+n} - \eta_0 &= 0, \end{aligned}\right\} \tag{8}$$

exigeons que le système (1), (8) soit complet.

On arrive aux équations:

$$\left.\begin{aligned} &\sum_{\rho=3}^{n} \frac{\partial \xi_\rho}{\partial x_\nu} p_{m+\rho} + \frac{\partial \xi_0}{\partial x_\nu} - \frac{\partial \Phi_\nu}{\partial x_{m+1}} - \frac{\partial \Phi_\nu}{\partial p_{m+1}} \left(\sum_{\rho=3}^{n} \frac{\partial \xi_\rho}{\partial x_{m+1}} p_{m+\rho} + \frac{\partial \xi_0}{\partial x_{m+1}} \right) - \\ &\quad - \frac{\partial \Phi_\nu}{\partial p_{m+2}} \left(\sum_{\rho=3}^{n} \frac{\partial \xi_\rho}{\partial x_{m+2}} p_{m+\rho} + \frac{\partial \xi_0}{\partial x_{m+2}} \right) - \\ &\quad - \sum_{j=3}^{n} \left[\frac{\partial \Phi_\nu}{\partial p_{m+j}} \left(\sum_{\rho=3}^{n} \frac{\partial \xi_\rho}{\partial x_{m+j}} p_{m+\rho} + \frac{\partial \xi_0}{\partial x_{m+j}} \right) - \frac{\partial \Phi_\nu}{\partial x_{m+j}} \xi_j \right] = 0, \\ &\sum_{\rho=3}^{n} \frac{\partial \eta_\rho}{\partial x_\nu} p_{m+\rho} + \frac{\partial \eta_0}{\partial x_\nu} - \frac{\partial \Phi_\nu}{\partial x_{m+2}} - \frac{\partial \Phi_\nu}{\partial p_{m+1}} \left(\sum_{\rho=3}^{n} \frac{\partial \eta_\rho}{\partial x_{m+1}} p_{m+\rho} + \frac{\partial \eta_0}{\partial x_{m+1}} \right) - \\ &\quad - \frac{\partial \Phi_\nu}{\partial p_{m+2}} \left(\sum_{\rho=3}^{n} \frac{\partial \eta_\rho}{\partial x_{m+2}} p_{m+\rho} + \frac{\partial \eta_0}{\partial x_{m+2}} \right) - \\ &\quad - \sum_{j=3}^{n} \left[\frac{\partial \Phi_\nu}{\partial p_{m+j}} \left(\sum_{\rho=3}^{n} \frac{\partial \eta_\rho}{\partial x_{m+j}} p_{m+\rho} + \frac{\partial \eta_0}{\partial x_{m+j}} \right) - \frac{\partial \Phi_\nu}{\partial x_{m+j}} \eta_j \right] = 0, \\ &\qquad \nu = 1, 2, \ldots, m; \end{aligned}\right\} \tag{9}$$

$$\sum_{\rho=3}^{n} \left[\left(\frac{\partial \eta_\rho}{\partial x_{m+1}} - \sum_{j=3}^{n} \xi_j \frac{\partial \eta_\rho}{\partial x_{m+j}} \right) - \left(\frac{\partial \xi_\rho}{\partial x_{m+2}} - \sum_{j=3}^{n} \eta_j \frac{\partial \xi_\rho}{\partial x_{m+j}} \right) \right] p_{m+\rho} +$$

$$+ \left[\left(\frac{\partial \eta_0}{\partial x_{m+1}} - \sum_{j=3}^{n} \xi_j \frac{\partial \eta_0}{\partial x_{m+j}} \right) - \left(\frac{\partial \xi_0}{\partial x_{m+2}} - \sum_{j=3}^{n} \eta_j \frac{\partial \xi_0}{\partial x_{m+j}} \right) \right] = 0; \tag{10}$$

$$p_{m+1} = \sum_{\rho=3}^{n} \xi_\rho p_{m+\rho} + \xi_0, \quad p_{m+2} = \sum_{\rho=3}^{n} \eta_\rho p_{m+\rho} + \eta_0. \tag{11}$$

Il est nécessaire, que les égalités (9), (10) deviennent des identités si l'on fait la substitution (11). De là un système d'équations linéaires aux dérivées partielles du premier ordre à plusieurs fonctions inconnues

$$\xi_3, \xi_4, \ldots, \xi_n, \eta_3, \eta_4, \ldots, \eta_n. \tag{12}$$

Si ce dernier système admet une solution, on peut adjoindre au système (1) les équations linéaires (8).

Cas particulier. Quand le système (1) est le système (6), on peut lui adjoindre les équations:

$$\left.\begin{aligned} p_{m+1} - \xi_3 p_{m+3} - \ldots - \xi_n p_{m+n} &= 0\ (2), \\ p_{m+2} - \eta_3 p_{m+3} - \ldots - \eta_n p_{m+n} &= 0 \end{aligned}\right\} \tag{13}$$

et ainsi de suite.

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MATHEMATIK

ÜBER EINE VERALLGEMEINERUNG DER UNGLEICHUNGEN VON S. BERNSTEIN UND H. BOHR

Von B. LEWITAN

(Vorgelegt von S. N. Bernstein, Mitglied der Akademie, d. 27. III. 1937)

Es sei $f(x)$ $(-\infty < x < \infty)$ eine messbare und beschränkte Funktion und

$$E(\alpha) = \frac{1}{2\pi}\int_{-\infty}^{\infty} f(x)\,\frac{e^{-i\alpha x} - L(\alpha x)}{-x^2}\,dx,$$

wo

$$L(\alpha x) = \begin{cases} 1 - i\alpha x & \text{für} \quad |x| \leqslant 1, \\ 0 & \text{für} \quad |x| > 1, \end{cases}$$

die verallgemeinerte Fouriersche Transformierte [in Sinne von H. Hahn (1)] von $f(x)$.

Es sei ferner

$$S_n(x; N) = \sum_{k=-n}^{n} \frac{n}{N}\left\{ E\left(\frac{k+1}{n}N\right) - 2E\left(\frac{k}{n}N\right) + E\left(\frac{k-1}{n}N\right)\right\} e^{i\frac{k}{n}Nx}.$$

Hilfssatz I. *Ist $E(\alpha)$ eine lineare Funktion für $\alpha > N > 0$ und $\alpha < -N$, so kann man für jedes $\varepsilon > 0$ ein n derart finden, dass*

$$\int_{-\infty}^{\infty} |f(x) - S_n(x; N)|^2 \frac{\sin^4 x}{x^4}\,dx < \varepsilon.$$

Beweis. Ist

$$T_n(\alpha) = \frac{1}{2\pi}\int_{-\infty}^{\infty} S_n(x; N)\,\frac{e^{-i\alpha x} - L(\alpha x)}{-x^2}\,dx$$

gesetzt, so sieht man leicht an, dass die Kurve $y = \Delta^2 T_n(\alpha)$, wo

$$\Delta^2 T_n(\alpha) = \frac{T_n(\alpha+2) - 2T_n(\alpha) + T_n(\alpha-2)}{4} = \frac{1}{2\pi}\int_{-\infty}^{\infty} S_n(x; N)\,\frac{\sin^4 x}{x^4}\,e^{-i\alpha x}\,dx =$$

$$= \frac{1}{2}\sum_{\left|\frac{kN}{n}-\alpha\right|<2} \frac{n}{N}\left\{ E\left(\frac{k+1}{n}N\right) - 2E\left(\frac{k}{n}N\right) + E\left(\frac{k-1}{n}N\right)\right\} \cdot \left\{1 - \frac{1}{2}\left|\frac{kN}{n} - \alpha\right|\right\}$$

ein in die Kurve $y = \Delta^2 E(\alpha)$ eingeschriebenes Streckenpolygon ist, welches mit dieser Kurve in den Punkten $\alpha = \frac{mN}{n}$ (m beliebig ganz) zusammenfällt.

Aus den Bedingungen des Hilfssatzes folgt daher für genügend grosses n, dass

$$\int_{-\infty}^{\infty} |\Delta^2 E(\alpha) - \Delta^2 T_n(\alpha)|^2 d\alpha = \int_{-N-2}^{N+2} |\Delta^2 E(\alpha) - \Delta^2 T_n(\alpha)|^2 d\alpha < \frac{\varepsilon}{2\pi},$$

und also ist nach dem Parsevalschen Satze für gewöhnliche Fouriersche Integrale:

$$\int_{-N-2}^{N+2} |\Delta^2 E(\alpha) - \Delta^2 T_n(\alpha)|^2 d\alpha = \frac{1}{2\pi} \int_{-\infty}^{\infty} |f(x) - S_n(x; N)|^2 \frac{\sin^4 x}{x^4} dx$$

und

$$\int_{-\infty}^{\infty} |f(x) - S_n(x; N)|^2 \frac{\sin^4 x}{x^4} dx < \varepsilon,$$

was zu beweisen war.

Hilfssatz II. *Falls unter den Bedingungen des Hilfssatzes I, die Funktion $f(x)$ stetig auf der ganzen Achse $-\infty < x < \infty$ ist, so strebt $S_n(x; N)$ und zwar gleichmässig in jedem endlichen Intervalle gegen $f(x)$ für $n \to \infty$.*

Beweis. Da $S_n(x; N)$ im Mittel gegen $f(x)$ konvergiert, so genügt es zu zeigen, dass $S_n(x; N)$ eine gleichmässig beschränkte und gleichartig stetige Folge bildet.

Es sei

$$\sigma_n(x; N; \mu) = \sum_{k=-\mu n}^{\mu n} \left(1 - \left|\frac{k}{n\mu}\right|\right) \left\{ \frac{E\left(\frac{k+1}{n}N\right) - 2E\left(\frac{k}{n}N\right) + E\left(\frac{k-1}{n}N\right)}{\frac{N}{n}} \right\} e^{ik\frac{N}{n}x} =$$

$$= \frac{1}{\pi} \int_{-\infty}^{\infty} f(\xi) \frac{\sin^2 \frac{N\xi}{2n}}{\frac{N}{2n}\xi^2} \sum_{k=-\mu n}^{\mu n} \left(1 - \left|\frac{k}{n\mu}\right|\right) e^{ik\frac{N}{n}(x-\xi)} d\xi,$$

wo μ eine natürliche Zahl bedeutet.

Folglich ist:

$$|\sigma_n(x; N; \mu)| \leqslant \frac{M}{\pi} \int_{-\infty}^{\infty} \frac{\sin^2 \xi}{\xi^2} \sum_{k=-\mu n}^{\mu n} \left(1 - \left|\frac{k}{n\mu}\right|\right) e^{ik\frac{N}{n}x} e^{-2ik\xi} d\xi = M,$$

wo

$$M = \sup |f(x)|.$$

Für $\mu \to \infty$ erhalten wir:

$$|S_n(x; N)| \leqslant M.$$

Nach dem bekannten Satze von S. Bernstein ist

$$\text{a) } |S_n'(x; N)| \leqslant N \cdot M, \qquad \text{b) } |S_n''(x; N)| \leqslant N^2 \cdot M. \tag{1}$$

Daraus folgt die gleichartige Stetigkeit der Funktionen $S_n(x; N)$, $S_n'(x; N)$, und der Hilfssatz ist bewiesen.

Da die Folge $S_n'(x; N)$ gleichartig stetig und gleichmässig beschränkt ist, so kann man nach dem Satze von Arzelà eine solche Unterfolge auswählen, welche gleichmässig konvergent in jedem endlichen Intervalle ist, und man sieht leicht an, dass die Grenzfunktion einzig und gleich $f'(x)$ ist *.

Ungleichheit I. (Die verallgemeinerte Ungleichheit von S. Bernstein.)

Unter den Bedingungen des Hilfssatzes II *folgt aus der Ungleichheit*

$$|f(x)| \leqq M \qquad (-\infty < x < \infty)$$

die Ungleichheit

$$|f'(x)| \leqq N \cdot M \qquad (-\infty < x < \infty). \tag{2}$$

Beweis. Da $S_n'(x; N)$ gleichmässig in jedem endlichen Intervalle gegen $f'(x)$ konvergiert, so folgt die Ungleichheit (2) aus der Ungleichheit (1, a) nach dem Grenzübergange $n \to \infty$.

Ungleichheit II. (Die verallgemeinerte Ungleichheit von H. Bohr.)

Es sei $f(x)$ eine beschränkte messbare Funktion, für welche $E(\alpha)$ im Intervalle $|\alpha| < N$ eine lineare Funktion ist.

Dann folgt aus $|f(x)| \leqq M$ die Ungleichheit

$$\left| \int f(x)\, dx \right| \leqq \frac{\pi}{2} \cdot \frac{M}{N},$$

wo die Integrationskonstante derart gewählt ist, dass die Fourier-Hahnsche Transformierte von $\int f(x)\, dx$ ebenfalls linear in $|\alpha| < N$ ist.

Beweis. Wir nehmen die Funktionen

$$f^{(k)}(x) = \frac{3}{2\pi} \int_{-\infty}^{\infty} f\left(x + \frac{2u}{k}\right) \frac{\sin^4 u}{u^4}\, du.$$

Bekanntlich (2) ist die Fourier-Hahnsche Transformierte von $f^{(k)}(x)$ eine lineare Funktion für $\alpha > 2k$ und $\alpha < -2k$ und, nach der Bedingung, noch für $|\alpha| < N$.

Ferner ist $f^{(k)}(x)$ eine stetige Funktion von x bei beliebigem k und

$$|f^{(k)'}(x)| \leqq M.$$

Es sei $S_n^{(k)}(x; 2k)$ ebenso für $f^{(k)'}(x)$ konstruiert, wie oben $S_n(x; N)$ für $f(x)$.

Nach der Ungleichheit von H. Bohr (3) ist

$$\left| \int S_n^{(k)}(x; 2k)\, dx \right| \leqq \frac{\pi}{2} \frac{M}{N},$$

wo $\int S_n^{(k)}(x; 2k)\, dx$ das unbestimmte Integral ohne freihes Glied bedeutet.

Setzt man

$$\int S_n^{(k)}(x; 2k)\, dx = C(n, k) + \int_0^x S_n^{(k)}(x; 2k)\, dx,$$

---

* Die Tatsache, dass unter den Bedingungen des Hilfssatzes II die Funktion $f(x)$ differenzierbar ist, ist bekannt (2).

so ergibt sich

$$|C(n,k)| \leqslant \frac{\pi}{2}\frac{M}{N}, \qquad \left|\int_0^x S_n^{(k)}(x;2k)\,dx\right| \leqslant \frac{\pi M}{N}.$$

Da

$$\lim_{n\to\infty} S_n^{(k)}(x;2k) = f^{(k)}(x),$$

so ist

$$\left|\int_0^x f^{(k)}(x)\,dx\right| \leqslant \frac{\pi M}{N}.$$

Anderseits kann man eine unendliche Unterfolge $\{n_m\}$ derart finden, dass

$$\lim_{m\to\infty} C(n_m,k) = C(k)$$

existiert.

Also ist

$$\left|C(k) + \int_0^x f^{(k)}(x)\,dx\right| \leqslant \frac{\pi}{2}\frac{M}{N}.$$

Es sei $k\to\infty$; führt man einen weiteren Auswahl aus, so ergibt sich, dass

$$\left|C + \int_0^x f(x)\,dx\right| \leqslant \frac{\pi}{2}\frac{M}{N}.$$

Es ist leicht zu sehen, dass die Fourier-Hahnsche Transformierte von

$$C + \int_0^x f(x)\,dx$$

linear in $|\alpha| < N$ ist.

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ASTRONOMY

THE ELEMENTS OF THE ORBIT OF THE «NEUJMIN II» COMET AS COMPUTED FROM THE CONNECTION BETWEEN ITS APPEARANCES IN 1916 AND 1927

By G. N. NEUJMIN

(Communicated by S. I. Wawilow, Member of the Academy, 23. III. 1937)

The periodic comet «Neujmin II», discovered at Simeiz on February 24, 1916, and having a period of 5.43 years, was observed at its two appearances: in 1916 and in 1926/7. No observations of the comet could be made at its odd returns into its perihelion in 1921 and 1932 on account of its unfavourable position with regard to the Earth and the Sun. Its next return into its perihelion, due in November 1937, will again be rather favourable to observation. To forecast its return with certainty, a more reliable orbit of the comet must first of all be computed from a connection between its two preceding appearances.

This has been the object of our work for the last few years. The starting points of our computations were supplied by the following elements of the orbit calculated as final from its appearance in 1916 ([1]).

Epoch and osculation — 1916 April. 10.0 mean Greenwich time

	M_0	5°	23′	25″. 27				
	ω	193	46	48. 76*		φ 34°29′19″.48		
1925.0	Ω	327	40	26. 37		n 653″.65531		(I)
	i	10	37	38. 11		$\log a$ 0.4897719		

T 1916 March 11.3127 mean Greenwich time
P 1982.7 days = 5.428 years

Making an allowance for the disturbances due to Jupiter during the period 1916—1926, this system of elements represented the first observations of 1926 subject to corrections:

$$\Delta\alpha = -7^m.6; \quad \Delta\delta = +1°13',$$

which corresponds to a correction of the time of the passage through the perihelion

$$\Delta T = +3.56 \text{ days}.$$

* Erroneously given as 48″.66 in «Bull. Obs. Centr. Poulkovo», № 99, p. 576.

In order to establish a full connection between the two appearances, it was necessary to compute the exact disturbances due to any planet that might have had an appreciable influence on the motion of the comet in the period of time 1916—1927. It was desirable to base these vast computations on a system of elements more precise than was (I). The first stage of our work was therefore to correct the elements of (I) on the ground of a preliminary connection between the appearances of 1916 and 1917, taking into account the disturbances due to Jupiter and Saturn (²). As a result, we obtained the system:

Epoch and osculation—1916 April, 10.0 mean Greenwich time

	M_0	5°	23′	5″.74			
	ω	193	47	3.15	φ	34° 30′ 14″.60	
1925.0	Ω	327	40	18.31	n	653″.09341	(II)
	i	10	37	43.19	$\log a$	0. 490 0209	

This system, while representing the normal points of the 1916 comet within a range of 2″, represents at the same time (taking into account the disturbances due to Jupiter and Saturn), within 1′, the observations of 1926 7, thus being accurate enough to be taken as a basis of a computation of exact disturbances.

The next step in our work was to calculate the exact disturbances of the elements of the comet due to 6 planets: Uranus, Saturn, Jupiter, Mars, Earth and Venus, for the period: 1916 February 10.0 mean Greenwich time to 1927 July 2.0 universal time. This long and laborious task enabled us to compile tables for the integration of disturbances for any moment comprised in the period under consideration.

Even after an allowance had been made for all these disturbances, the system of elements (II) did not, however, represent the observations of 1926 7 with a precision that would have justified its being taken as a basis of the final solution ($\Delta\alpha$ of the order of 1^m, $\Delta\delta$ of the order of 10′). Another preliminary improvement of the elements was therefore undertaken, an allowance being made for all the disturbances. As a result, the following system was obtained:

Epoch and osculation: 1916 April, 10.0 mean Greenwich time

	M_0	5°	23′	3″.10			
	ω	193	47	5.09	φ	34° 30′ 22″.04	
1925.0	Ω	327	40	17.22	n	653″.01751	(III)
	i	10	37	43.89	$\log a$	0.4900545	

System (III) was taken as a basis for the final improvement of the orbit.

During the appearance of the comet in 1926 7, it was unfortunately observed but little, in the 4 months of its visibility only 22 observations having been made at three observatories (Yerkes, Johannesburg and Simeiz). Out of this total, three had to be rejected as unsatisfactory. On the ground of the remaining observations, 5 normal points were drawn up, their weight, however, being but small. In addition to the 8 normal points of 1916, this gave a total of 13 normal points to be comprised in the final solution. In solving, however, the equations, it became necessary to eliminate one of them—that of 1927 March 9.0—as based on two not fully reliable observations. The most satisfactory solution, based on 12 normal points, gave the final system of elements shown below:

Epoch and osculation: 1916 April, 10.0 mean Greenwich time

$$1925.0 \quad \left\{ \begin{array}{llll} M_0 & 5^\circ\ 23'\ 4''.19 & & \\ \omega & 193\ 47\ 0.04 & \varphi & 34^\circ\ 30'\ 21''.90 \\ \Omega & 327\ 40\ 17.71 & n & 653''.01\ 938 \\ i & 10\ 37\ 44.34 & \log a & 0.\ 490\ 0537 \end{array} \right\} \quad \text{(IV)}$$

T 1916 March 11.3161 mean Greenwich time

P 1984.6 days = 5.434 years

This solution reduces the sum of the squares of the residual errors $[p\rho^2]$ from 3795″ to 462″ and gives for the probable error of an equation of weight 1

$$p = \pm 3''.44.$$

An analysis of the residual errors reveals a certain system in their variation within every appearance (more especially, within the second one), which makes it impossible to regard the elements (IV) as definitive in the full acceptation of the word. This may be due to the fact that, while the disturbances between the two appearances had been computed with the elements (II), they ought to have been based on the elements (IV). Owing to the similarity of these two systems of elements, the disturbances of most elements will be changed to an inappreciable extent by the substitution of system (IV) for system (II), the change being of the order of a few hundredths of a second of an arc, the only exception to this being the disturbance of the mean anomaly, which will be changed by a value of the order of +7″. This question will be discussed later.

At this stage of our knowledge, the system of elements (IV) may at any rate be regarded as the most probable result of the connection established between the observed appearances of the comet. Even if a greater degree of precision is achieved, the resulting change of the system can be but insignificant.

Adding to the elements (IV) the disturbances due to 6 planets as shown in our tables, we reduce them to the epoch of the latest appearance observed. Taking for such an epoch 1927 March 4.0 universal time, we obtain:

Disturbances due to 6 planets from 1916 April 10.0 to 1927 March 4.0

$$\left\{ \begin{array}{l} \delta i + 1''.43 \\ \delta\Omega - 93.80 \\ \delta\varphi + 81.39 \\ \delta\omega - 175.14 \\ \delta M_0 + 460.88 \\ \delta M_n + 4029.54 \\ \delta n + 0''.46600 \end{array} \right.$$

Elements

Epoch and osculation: 1927 March, 4.0 universal time

$$1925.0 \quad \left\{ \begin{array}{llll} M_0 & 8^\circ\ 29'\ 25''.23 & & \\ \omega & 193\ 44\ 4.90 & \varphi & 34^\circ\ 31'\ 43''.29 \\ \Omega & 327\ 38\ 43.91 & n & 653''.48\ 538 \\ i & 10\ 37\ 45.77 & \log a & 0.489\ 8472 \end{array} \right\} \quad \text{(IVa)}$$

T 1927 January 16.2273 universal time

P 1983.2 days

The system of elements (IVa), which differs from (IV) by the disturbances only, has been taken as a basis for the forecast of the forthcoming appearance of the comet.

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PHYSICAL CHEMISTRY

ON THE DEPENDENCE OF THE RATE OF PHOTOCHEMICAL REACTIONS IN SOLUTION ON THE CONCENTRATION OF REAGENTS

By B. J. SVEŠNIKOV

(Communicated by S. I. Wawilow, Member of the Academy, 31. III. 1937)

Elsewhere (1) we put forward the hypothesis that the constant of a bimolecular reaction in solution could be considered at the first approximation as a function of three parameters: the energy of activation, the mean life of the molecule in the active state and the number of effective collisions between the molecules of both components of the reaction. It was noted in that paper that the dependence of the rate of reaction on viscosity, which is not rarely observed, obliged us to suppose that for many reactions the mean life of the molecule in the active state was considerably greater than the time between two consecutive solute-solvent-collisions. This conclusion can also be arrived at by taking into account the fact that the velocity of reaction is often decreased by the increasing concentration of the reagents. To consider in greater detail the latter phenomenon is an object of the present article.

The deductions given below are, strictly speaking, quite correct only for the particular case of some non-reversible photochemical reactions, since they are based on the following suppositions.

1. We suppose that the reaction takes place when the molecule of a definite reagent has been in some manner activated, the state of the molecules of the second reagent having no influence on the success of the reaction.

2. The disactivation of active molecules is controlled by the law of monomolecular reaction.

3. The appearance of new molecules produced by the reaction does not alter the conditions of activation or disactivation of other molecules.

We now denote the number of all molecules of the first component, the activation of which is necessary for the success of the reaction, through n_0, and the number of the molecules of the second component through c. For any moment of time we have

$$n_0 = n_1 + n_2 + n_3, \tag{1}$$

where n_1 is the number of excited molecules by that moment,
n_2 is the number of unexcited molecules by that moment,

n_3 is the number of molecules produced by the reaction by that moment.

It is evident that the number of the molecules of the first reagent which have become activated in the interval of time between t and $t + dt$, is proportional to the number of the unexcited molecules of the same reagent, i. e. equal to

$$\alpha n_2 dt, \tag{2}$$

where α is the coefficient of proportionality.

The number of molecules, which have been disactivated in the same interval of time is

$$\beta n_1 dt, \tag{3}$$

where β is the probability of disactivation and

$$\beta = \frac{1}{\tau}. \tag{4}$$

Here τ denotes the mean life of the molecules of the first reagent in the active state.

Finally, the number of molecules which are reacting within the interval of time from t to $t + dt$ is

$$k(c - n_3) n_1 dt. \tag{5}$$

If the mean life of the molecule in the active state has a value between $10^{-12} - 10^{-13}$ sec., the excited molecules can react only with those molecules of the second reagent which are separated from it by distance equal to the free path and, as shown by the writer (1), the constant of reaction k must be independent of viscosity. If the mean life of the molecule in the active state has, however, a value of about 10^{-9} sec., the value of k must be determined by using diffusion calculations:

$$k = 4\pi pDR \tag{6}$$

where D is the coefficient of diffusion; R, the radius of the sphere of action, and p, the probability of reaction due to a «set» of collisions between two molecules.

The value of this probability is a function of viscosity owing to the influence of repeated collisions (1).

From (2), (3) and (5) we have obviously

$$\frac{dn_1}{dt} = \alpha n_2 - [k(c - n_3) + \beta] n_1, \tag{7}$$

$$\frac{dn_2}{dt} = \beta n_1 - \alpha n_2, \tag{8}$$

$$\frac{dn_3}{dt} = k(c - n_3) n_1. \tag{9}$$

In the general case the solution of this system of equations is very difficult; therefore we confine ourselves to the consideration of a case where

$$c \gg n_0.$$

We have then, taking into account (1):

$$\frac{dn_1}{dt} = \alpha(n_0 - n_1 - n_3) - (kc + \beta) n_1, \tag{10}$$

$$\frac{dn_3}{dt} = kcn_1. \tag{11}$$

Eliminating n_3 from (10) and (11) we obtain

$$\frac{d^2n_1}{dt^2} + (\alpha + \beta + kc)\frac{dn_1}{dt} + \alpha kcn_1 = 0. \tag{12}$$

The characteristic equation for (12) has real roots only, and the general solution of (12) is

$$n_1 = C_1 e^{-(a-b)t} + C_2 e^{-(a+b)t}, \tag{13}$$

where

$$a = \frac{1}{2}(\alpha + \beta + kc), \tag{14}$$

$$b = \sqrt{a^2 - \alpha kc}. \tag{15}$$

Since the initial conditions for (13) are:

$$n_1 = 0 \qquad \text{at } t = 0, \tag{16}$$

$$\frac{dn_1}{dt} = \alpha n_0 \qquad \text{at } t = 0, \tag{17}$$

then

$$C_1 = -C_2 \tag{18}$$

and

$$C_1 = \frac{\alpha n_0}{2b}. \tag{19}$$

Consequently

$$n_1 = \frac{\alpha n_0}{2b}\left\{ e^{-(a-b)t} - e^{-(a+b)t} \right\}. \tag{20}$$

For n_3 we have obviously from (11)

$$n_3 = kc \int_0^t n_1\, dt + C_3. \tag{21}$$

Under initial and final conditions

$$n_3 = 0 \quad \text{at} \quad t = 0, \tag{22a}$$

$$n_3 = n_0 \quad \text{at} \quad t = \infty. \tag{22b}$$

From (21), taking into account (22), and eliminating $\alpha kc = a^2 - b^2$, we have

$$n_3 = n_0\left[1 - \frac{1}{2b}\left\{(a+b)\,e^{-(a-b)t} - (a-b)\,e^{-(a+b)t}\right\}\right]. \tag{23}$$

The formula (23) can be easily simplified. The coefficient α, which determines the ratio of the molecules that are being excited to the number of the unexcited ones, is usually much less than the coefficient of disactivation β. In the case of optical excitation this can be proved experimentally. If the value of α really were of the same order of magnitude as β, the existence of excited molecules could be detected by an alteration in the power of absorption of an intensely illuminated solution.

The experiments of Wawilow and Lewschin [2] showed, however, the absence of this effect even in those fluorescent substances which have a relatively high value of τ ($> 1 \cdot 10^{-6}$ sec).

We may assume, consequently, that in all cases

$$\alpha \ll \beta. \tag{24}$$

Developing (15) into a series and confining ourselves to the first members we obtain

$$b = a - \frac{1}{2}\frac{\alpha kc}{\sigma}. \qquad (25)$$

Substituting for b in (23) its value from (25) and assuming that t is not very small, we obtain

$$n_3 = n_0\left[1 - e^{-\frac{\alpha kc}{2a}t}\right] \qquad (26)$$

since

$$e^{-(a+b)t} \ll e^{-(a-b)t},$$

and

$$a + b \approx 2b.$$

The formula (26) coincides with the usual expression for a pseudo-monomolecular reaction. However, our deduction, contrary to the formal deduction adopted in chemical literature, allows us to arrive at an important conclusion. The usual purely formal deduction gives for the number of molecules produced by the reaction in the case of a pseudo-monomolecular reaction the following expression:

$$n = n_0\left[1 - e^{-k'ct}\right], \qquad (27)$$

where k' is not dependent on the concentration of the reagents.

In formula (26) the coefficient corresponding to

$$\frac{\alpha k}{2a} = \frac{2\alpha k}{\alpha + \beta + kc} \approx \frac{2\alpha k}{\beta + kc} = k' \qquad (28)$$

depends evidently on the concentration of the second reagent, and the constant of velocity treated in the usual sense must decrease with the increase of concentration of that component.

From formula (28) we may at once see the connection between the variation of the constant of the reaction and that of τ. The greater τ (i. e. the smaller β), the lower are the concentrations of the reagents needed to render noticeable the decrease of the constant of the reaction. This enables us to determine the value of τ, if we know the decrease of the constant of the reaction with the concentration of the reagents.

By way of example, we shall determine the order of magnitude of τ in the photochemical reaction of discolouring of Lautsche Violett, which was investigated by K. Weber ([3]). L. V. is reduced by illuminating if an acceptor is added to the dye-solution *.

The experiments of Weber are in agreement with our scheme since in his investigations the concentrations of the acceptor were constantly greater than those of the dye-stuff ($3.79 \cdot 10^{-5}$ mol/litre). The table shows Weber's data, which illustrate the dependence of the time needed for discolouring on the concentration of the acceptor.

From formula (27) and (28) it follows obviously that

$$\frac{t_2}{t_1} = \frac{(\beta + kc_2)\,c_1}{(\beta + kc_1)\,c_2}, \qquad (29)$$

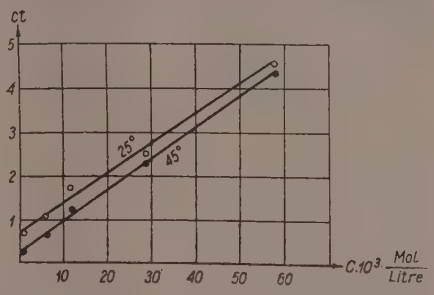
or

$$\frac{t_2 c_2}{t_1 c_1} = \frac{\beta + kc_2}{\beta + kc_1}. \qquad (30)$$

* In Weber's experiments diethyl-*b*-allyl-urea was used as acceptor.

Concentration of acceptor in $\frac{\text{mol}}{\text{litre}}$	Time of discolouring in sec.	
	$T = 25°$	$T = 45°$
$0.58 \cdot 10^{-3}$	1 260	485
$5.80 \cdot 10^{-3}$	190	115
$11.60 \cdot 10^{-3}$	150	105
$29.00 \cdot 10^{-3}$	85	80
$58.00 \cdot 10^{-3}$	80	75

Consequently there must be a linear dependence between tc and c. The figure shows that in the case investigated by Weber this dependence holds well enough. This justifies in turn the above assumption that the disactivation of excited molecules is controlled by an exponential law.



If we now suppose that the efficiency of the encounter of the molecules of the dye and those of the acceptor is equal to 1, and calculate k from (6), supposing $R \approx 1 \cdot 10^{-7}$ cm (the sum of kinetic radii) and $D \approx 1 \cdot 10^{-5}$ cm² sec^{-1} ($\eta = 0.01$), we may, by using the table, determine the value of

$$\beta \approx 6.5 \cdot 10^{7}.$$

Consequently

$$\tau = \frac{1}{\beta} \approx 1.5 \cdot 10^{-8} \text{ sec.}$$

This value approaches the usual value of the mean life of the dye molecules in excited state.

In Weber's experiments the concentration of the first component was constant, and the decrease of the reaction constant was produced only by an increase in the concentration of the second (unexcited) component. In the case of a simultaneous increase in the concentration of both reaction components, another cause is possible for the decrease of the reaction rate constant namely: the constant of reaction may decrease with the decrease of τ owing to the disactivation of the excited molecules by the unexcited molecules of the same reagent, i. e., a phenomenon analogous to the quenching of fluorescence may take place.

As shown by N. G. Morosova and myself*, the quenching of fluorescence of fluorescein by foreign substances is in fact considerably decreased in the region of the concentration quenching of the dye-stuff.

As far as the order of magnitude is concerned, this decrease is in agreement with the data of Szymanovski ([4]), who used a fluoremeter to measure the decrease in the mean life in the active state of fluorescein molecules in the region of the concentration quenching of the dye-stuff.

* B. J. Svešnikov, Diss. in the press.

In conclusion, I wish to put on record my profound gratitude to S. I. Wawilow, Member of the Academy, and also to M. G. Veselov, for their help in the present work.

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GEOLOGIE

ÜBER DIE FOSSILEN PFLANZENRESTE IM LÖSS UND IN DEN LÖSSARTIGEN LEHMEN IM ZUSAMMENHANG MIT DER FRAGE ÜBER DIE ENTSTEHUNG DIESER ABLAGERUNGEN

Von V. SUKAČEV, korrespondierendem Mitglied der Akademie, und S. DOLGAJA

Der Löss bleibt auch jetzt noch, trotz einer grossen Anzahl von wissenschaftlichen Untersuchungen, ein ungelöstes Problem. Wenn auch zur Zeit, besonders dank den von L. S. Berg veröffentlichten Arbeiten ([1], [2], [3]), als hinreichend begründet angenommen werden darf, dass Löss und lössartige Lehme die sie kennzeichnenden Eigenschaften aus den verschiedenartigsten Ablagerungen durch Verwitterung und Bodenbildungsprozesse in trockenen Klimaverhältnissen entnehmen können, so ist trotzdem die Entstehung der Urgesteine des Lösses und der lössartigen Lehme im süd-europäischen Teil der UdSSR und in Sibirien nicht als festgestellt zu betrachten. Dieses lässt sich unzweifelhaft durch die Armut derselben an paläontologischem Material erklären.

Unter anderem muss bemerkt werden, dass mikroskopische Untersuchungen des Lösses auf Pollen und Sporen bis auf weiteres zu keinem Ergebnis geführt haben. Indessen haben wir bei Anwendung der Touletschen Flüssigkeit nach dem von Gričuk ausgebildeten Verfahren ([4]) feststellen können, dass im Löss und in dem darin eingebetteten Boden sowohl Pollen und Sporen, als auch einige andere Pflanzenreste angetroffen werden können.

Als Ausgangsmaterial für diese Untersuchungen dienten Lösse und lössartige Lehme, die von V. N. Sukačev unter Beihilfe von A. V. Snigireva und M. V. Zavjalov im südwestlichen Teil des Gebiets Kursk gesammelt wurden. Ausserdem wurden Lössproben aus den Schürfungen im «Ersten-Mai-Garten» in Kiew untersucht, sowie lössartige Lehme aus der Stadt Lichwin (auf den bekannten interglazialen Ablagerungen) und aus der Umgegend von Tobolsk und des Dorfes Kriwoscheïno am Ob (60 km unterhalb der Mündung des Tomj).

Im Gebiet Kursk wurden die Quartärablagerungen am Oberlauf des Flusses Worskla unweit Borissowka und Tamarowka, d. h. im Extraglazialgebiet untersucht.

Hier zeigen die Schluchten, welche die 200—210 m über dem Meeresspiegel gelegene Hochebene durchschneiden, dass der Untergrund überall aus lössartigem Lehm von 4—6 m Mächtigkeit besteht, unter dem noch einige durch fossile Böden voneinander getrennte Stufen lössartiger Lehme lagern. Meistenteils finden sich drei Bodenhorizonte, von denen jeder eine Mächtig-

keit von 25 cm bis 1 m besitzt; es bestehen also, ausser der obersten Stufe, noch drei Stufen lössartiger Lehme. An gewissen Profilen konnten sogar sechs Stufen lössartiger Lehme und fünf Stufen fossiler Böden unterschieden werden. Je tiefer der Horizont des lössartigen Lehms gelagert ist, desto schwächer, und das ist die Regel, sind in ihm die für den Löss typischen Merkmale ausgeprägt und desto schärfer tritt eine horizontale Schichtung in ihm zu Tage. Die zwei (oder drei) oberen fossilen Böden sind schwarzerdeartig, der unterste dagegen ist gewöhnlich Podsolboden. Unter allen Böden, auch unter dem Podsolboden, befinden sich zahlreiche alte Maulwurfshölen. In diesem Falle hat sich augenscheinlich der Schwarzerdeboden erst späterhin durch Degradation in Podsolboden verwandelt. Unterhalb dieser lössartigen Lehme lagern weniger mächtige schichtige Sand- oder Ton- und Lehmseeablagerungen, die zuweilen stark durch Humus gefärbt sind (z. B. in der Nähe des Dorfes Mongotnja am Fluss Gotnja). Dieselben werden von tertiären Sanden unterlagert. Nur in der Schlucht beim Dorfe Lantuchowka am Flusse Gotnja erwiesen sich unter dem (von oben gerechneten dritten) Podsolboden noch zwei aus lössartigen Lehmen bestehende Horizonte, die durch einen gut ausgeprägten Boden getrennt waren und Maulwurfshöhlen enthielten. Die letzte dieser Lehmstufen besass ganz unten eine ziemlich ausgeprägte Humusfärbung. Die gesamte Mächtigkeit aller lössartigen Horizonte mit den sie durchschichtenden Böden betrug meistens 15—20 m.

Der zweite von den im Gebiet Kursk erforschten Bezirken ist am Flusse Sseim in der Nähe der Dörfer Wyssokij Poljatschok und Jurassowka gelegen. Diese Gegend befindet sich bereits im Glazialgebiet und zwar am östlichen Rande desselben. Hier lagert gewöhnlich über Geschiebelehm (Moräne) ein gut ausgebildeter Boden, am häufigsten Podsolboden, der ebenfalls zahlreiche Maulwurfshöhlen aufweist. Darüber lagern drei, zuweilen sogar vier Stufen Löss, die durch zwei bez. drei schwarzerdeartige Böden getrennt sind. Unterhalb des Geschiebelehms, der in seinem oberen Teil nicht selten ausgesprochen lössartig ist, liegen schichtige Sande, Tone und Lehme, die an einigen Stellen durch Süsswassermergel oder stark humussierte Moorablagerungen ersetzt sind. Die Gesamtmächtigkeit der Quartärablagerungen erreicht hier meist 20—25 m, von denen 10—12 m auf die Lösse oberhalb des Geschiebelehms entfallen. Übrigens ist stellenweise sowohl in dieser Gegend, als auch am Flusse Worskla die Quartärablagerung weniger mächtig und einfacher in ihrem Aufbau und hat eine geringere Anzahl von Lösstufen und fossilen Böden.

Mikroskopisch untersucht wurden sowohl Proben von Lössen und lössartigen Lehmen verschiedener Stufen, als auch Proben fossiler Böden. Es fanden sich Sporen und Pollen, sowie sehr kleine Holzreste, die vorzugsweise aus wenigen Gefässen oder Tracheïden und einigen Markstrahlzellen bestanden.

Die gefundene Anzahl von Pollen, Sporen und Holzresten war gewöhnlich nicht grösser als 4—5 Stück im Präparat (Fläche 648 mm^2); nicht selten jedoch waren auch solche Präparate, in denen jegliche Pflanzenreste fehlten.

Aufschluss über die Anzahl dieser Pflanzenreste und deren Verteilung in den verschiedenen Lösstufen und fossilen Böden gibt Tab. 1, die sich auf die Verhältnisse an der Schlucht Glubokij bei Borissowka am Flusse Worskla bezieht.

Ungefähr gleiche Werte ergaben die Pflanzenreste auch in den aus anderen Schürfungen entnommenen Proben. Eine Zusammenstellung derselben enthält Tab. 2.

Tabelle 1

Tiefe der Probeentnahme in *m*	Gesteine und Stufen / Pflanzenreste	Sporen						Pollen								Holzreste		Anzahl der Präparate
		Dryopteris thelypteris	*D. spinulosa*	*D. filix mas*	*Athyrium filix femina*	*Polypodium vulgare*	*Lycopodium selago*	*Picea*	*Pinus*	*Salix*	*Corylus*	*Betula*	*Alnus*	*Nymphaea*	*Tilia*	Tanne	Nadelhölzer	
2.5	Lössartiger Lehm 1. Stufe . . .	1	—	3	—	—	1	—	3	1	—	3	1	—	1	—	1	20
4.0	Lössartiger Lehm 1. Stufe . . .	—	—	3	—	—	1	—	—	—	—	2	—	—	—	—	—	10
5.0	Lössartiger Lehm 2. Stufe . . .	4	2	1	—	1	—	6	2	—	—	3	—	—	1	—	—	10
6.0	Lössartiger Lehm 3. Stufe . . .	—	—	2	2	1	—	—	—	—	—	2	2	—	—	—	—	10
6.4	3. eingebettete Boden	—	—	—	—	—	8	—	—	—	1	—	1	2	—	1	—	10
7.2	3. eingebettete Boden	—	—	—	—	—	6	—	—	—	—	—	—	3	—	1	—	10

Krokos ([5], [8]) und andere Geologen der Ukraine sind der Meinung, dass die Lösse bezüglich der Entstehungszeit ihres Ursprungsgesteins der Glazialzeit angehören, während die fossilen Böden sich auf den Lössen und Moränen in der Interglazialzeit gebildet haben. In Übereinstimmung damit stellt Krokos sechs Lösstufen fest und lässt deren Ablagerungen zeitlich mit den sechs Vergletscherungen in der Schweiz: Günz, Mindel, Präriss, Riss, Würm I und Würm II zusammenfallen. Dieser Auffassung nach wären oberhalb unseres Moränenlehms, der—wie allgemein angenommen wird—eine Rissgletscherablagerung darstellt, zwei Lösstufen zu erwarten. Indessen wurde schon oben darauf hingewiesen, dass im Glazialteil unseres Gebietes entschieden mit drei und zuweilen sogar mit vier Lösstufen zu rechnen ist. Auch eine Reihe von anderen Tatsachen deutet darauf hin, dass die von Krokos vertretene Ansicht einer Nachprüfung bedarf.

Dennoch lässt die Gesamtheit der uns zu Gebote stehenden geologischen Erkenntnisse annehmen, dass jene Gesteinsarten, denen die Lösse und lössartigen Lehme—zumindestens im Flussgebiet des Dnjepr—ihren Ursprung verdanken, in der Eiszeit abgelagert worden sind.

Bei der Bewertung der angeführten paläontologischen Angaben ist in Betracht zu ziehen, dass die in fossilen Böden vorkommenden Pflanzenreste verschiedenen Epochen angehören können. Sie können einerseits noch aus den Zeiten herstammen, in denen die Ursprungsgesteine des Lösses und der lössartigen Lehme und folglich auch der erwähnten fossilen Böden abgelagert wurden, anderseits aber auch aus einer Zeit herrühren, in der die Bildung dieser Böden selbst vor sich ging.

Tabelle 2

№	Benennung der Pflanzen	Oberlauf des Flusses Worskla: Bezirke: Borissowskij und Tamarowskij												Fluss Sseim Bezirk Gluschkowskij							Kiew	Lichwin		Tobolsk	Kriwoscheino am Flusse Ob		
		Lössartige Lehme				Fossile Böden								Löss		Fossile Böden										Lössartige Lehme		
		Hochebene			Terrasse																							
		1. Stufe	2. Stufe	3. Stufe	2. Terrasse	1. Horizont	2. Horizont	3. Horizont	5. Horizont	6. Horizont	Unter Löss lagernde schwarze Humusschichten			1. Stufe	3. Stufe	4. Stufe	1. Horizont	2. Horizont	4. Horizont	Unter Moränen lagernde schwarze Humusschichten	1. Lösstufe	Lössartige Lehme	Eingebettete Böden	Lössartige Lehme	1. Stufe	2. Stufe	3. Stufe
1	*Sphagnum medium*	—	—	—	—	—	—	—	—	—	+			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	*Sphagnum* sp.	—	—	—	+	—	—	—	—	—	+			—	—	—	—	—	—	+	—	—	—	+	—	—	—	—
3	*Woodsia ilvensis*	—	—	—	—	—	—	—	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	*Dryopteris thelypteris*	+	+	—	—	—	—	—	—	—	—			+	—	—	+	—	—	—	—	—	—	—	—	—	—	—
5	*D. spinulosa*	—	+	—	—	—	—	—	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	*D. filix mas*	+	+	+	—	—	—	—	—	—	+			—	—	+	—	—	—	—	—	—	—	—	—	—	—	—
7	*Athyrium filix femina*	—	+	+	—	—	+	—	—	—	—			+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8	*Polypodium vulgare*	—	+	+	—	—	—	—	—	—	—			—	—	+	—	—	—	—	—	—	—	—	—	—	—	—
9	*Lycopodium clavatum*	+	—	—	—	—	—	—	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	*L. annotinum*	+	—	—	+	—	—	—	—	—	+			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11	*L. selago*	+	—	—	—	—	—	+	—	—	—			—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
12	*L. complanatum*	—	—	+	—	—	—	—	—	—	—			—	—	—	—	+	—	—	—	+	—	—	—	—	—	—
13	*Selaginella* sp.	—	—	—	—	—	—	—	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—	—	—	+
14	*Abies*	—	—	—	—	—	+	—	—	—	—			—	—	—	—	—	—	—	—	+	—	—	—	—	—	—
15	*Picea*	+	+	—	+	—	—	—	—	—	+			—	—	—	—	—	—	—	+	+	—	+	—	—	+	—
16	*Pinus*	+	+	+	—	—	+	—	+	—	+			+	—	—	+	—	—	+	—	+	—	—	—	—	—	+
17	*Salix*	+	+	—	+	—	+	—	+	+	—			—	+	+	+	—	—	+	—	+	—	—	—	—	—	—
18	*Pirus carya*	—	—	—	—	—	—	—	—	—	—			—	—	—	+	—	—	+	—	—	—	—	—	—	—	—
19	*Carpinus*	—	—	—	—	—	—	—	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20	*Corylus*	—	—	—	—	+	—	—	—	—	+			—	—	—	—	—	—	—	+	+	—	—	—	—	—	—
21	*Betula*	+	+	+	—	+	+	+	+	—	+			+	+	+	+	—	+	—	+	+	—	+	—	+	—	+
22	*Alnus*	+	+	+	—	+	—	+	—	—	+			—	—	+	—	—	+	—	—	—	—	+	—	—	—	—
23	*Quercus*	—	+	—	—	—	—	—	—	—	+			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24	*Nymphaea*	—	—	—	—	—	+	—	—	—	+			—	—	—	—	—	—	—	—	—	—	—	—	+	—	+
25	*Tilia*	+	+	—	—	+	—	—	—	—	+			—	—	—	—	—	—	—	—	—	—	—	—	+	—	—
26	*Ericaceae*	—	—	—	—	—	+	—	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
27	Tannenholzreste	+	+	+	—	—	—	+	—	—	+			+	—	—	—	—	—	—	—	+	—	+	—	+	+	+
28	Holzreste von Koniferen	+	+	—	—	—	+	—	—	—	—			—	—	—	—	+	—	—	—	+	—	—	—	+	+	+
29	Laubholzreste	—	+	—	—	—	+	—	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Es darf auch die Frage aufgeworfen werden, ob der Fundort der im Löss und lössartigem Lehm erhalten gebliebenen Pflanzenreste nicht schon ein sekundärer ist, an dem dieselben zusammen mit dem sie umschliessenden Lössgestein abermals abgelagert wurden. Im Schrifttum finden sich Andeutungen über die Möglichkeit einer derartigen Wiederablagerung von Pflanzenpollen [Sukačev (7), Hyyppä (8), Iversen (9)]. Nicht ausgeschlossen ist auch die Möglichkeit, dass in die untersten Horizonte unseres lössartigen Lehms der Pollen teilweise aus den dieselben unterlagernden Seeablagerungen geraten ist. Für die oberen Lösschichten ist dieses jedoch wohl schwerlich zulässig. Zudem sind in lössartigen Lehmen ganze Stücke von Antheren mit Pollen und Sporangien mit Sporen angetroffen worden, ein Umstand, der gegen die Annahme spricht, dass dieselben sich an einem sekundären Fundort befänden.

Desgleichen ist es unwahrscheinlich, dass der Pollen in den Boden hineingewaschen wurde und daselbst bis zu den tiefsten Schichten des Untergrundes vordringen könnte. Gegen eine solche Annahme spricht auf das entschiedenste auch der Umstand, dass die fossilen Pflanzenreste sowohl in den oberen als auch den unteren Teilen einer und derselben Stufe der Lössablagerungen von gleichem Bestande sind und die Menge solcher Pflanzenreste in den oberen Horizonten nicht zunimmt.

Die verhältnismässig unbedeutende Menge an Sporen und Pollen, die in Lössablagerungen angetroffen wird, kann wohl dafür sprechen, dass der Pollen aus weiter Ferne hierher übertragen worden ist. Eine Antwort auf diese Frage findet man in den Arbeiten von Vareschi (10), nach dessen Untersuchungen in den Gletschern der Schweiz ein Kubikdezimeter bis durchschnittlich 350—1200 Pollenkörner enthält. Proben ohne Pollen oder Proben mit Pollen von mehr als 5000 Körnern auf ein Kubikdezimeter fanden sich bei ihm selten. Die Entfernung zwischen diesen Gletschern und den nächstliegenden Wäldern beträgt indessen bloss einige Kilometer. Wenn der Pollengehalt unserer lössartigen Lehme auf das Gesteinvolumen umgerechnet wird, so ergeben sich Werte, die den von Vareschi angegebenen naheliegen. Im allgemeinen jedoch enthalten reine Mineralablagerungen wenig Pollen. Dabei war im gegebenen Falle das Gestein im Verlauf der Lössbildung noch der Verwitterung ausgesetzt. Infolge dessen kann die von uns festgestellte Menge an Pollen, Sporen und Holzresten selbst dann, wenn wir eine Übertragung derselben durch den Wind annehmen, davon zeugen, dass unweit von hier sich Wälder befanden.

Auf Grund der obenangeführten Betrachtungen und gestützt auf eine Analyse der in Tab. 2 zusammengefassten Untersuchungsergebnisse lassen sich folgende Schlussfolgerungen aufstellen:

1. Die Anwesenheit von Holzresten, Waldfarnsporen und Pollen von Holzpflanzen in nahezu sämtlichen Proben der Lössablagerungen zeugt davon, dass die Wälder unweit des Ablagerungsortes jener Gesteine standen, aus denen sich hier die Lösse und lössartigen Lehme entwickelt haben. In der nördlichen Ukraine und in der Umgegend von Lichwin befanden sich Nadelwälder, aus Kiefer und Tanne bestehend, und Laubholzwälder mit Eiche, Linde, Hasel, Birke und Erle. In West-Sibirien wuchsen Nadelwälder, in denen aber auch Birke und Linde vorkamen. (Spuren der letzteren wurden bisher nur in den Schichten gefunden, die auf die Ablagerungszeit der Oberstufe des lössartigen Lehms Bezug haben.)

2. Der Bestand an Pollen, Sporen und Holzresten ist in der Hauptsache ziemlich gleichartig für die verschiedenen Stufen sowohl des Lösses, als auch der lössartigen Lehme des Kursk-Gebiets. Dieser Umstand kann ein

Zeugnis sein für die Gleichartigkeit der Verhältnisse, unter denen das Urgestein für den Löss und die lössartigen Lehme in den verschiedenen Zeitabschnitten des Pleistozäns abgelagert wurde.

3. Paläontologische Funde, die mit Bestimmtheit auf besonders niedrige Temperaturen zur Zeit der Ablagerung dieser Gesteine hindeuten würden, sind bisher nicht gemacht worden, abgesehen von dem recht häufigen Vorkommen der Sporen des *Lycopodium selago*, eines Gewächses, das der Tundra eigentümlich ist, jedoch auch in moosreichen Wäldern angetroffen wird. Ebensowenig beweiskräftig ist das Vorkommen der Sporen von *Woodsia ilvensis*, *Polypodium vulgare* und *Selaginella*, da diese Pflanzen nicht nur in der Tundra, sondern auch in der Waldzone auftreten.

4. Wenn der vorgefundene Pollen der *Nymphaea*, eines wenig Pollen aufweisenden und zum Lufttransport wenig befähigten Wassergewächses. Zeugnis davon ablegt, dass die lössartigen Lehme West-Sibiriens in Wasserbehältern abgelagert wurden, so spricht auch die Anwesenheit von Holzresten, ganzen Sporangien und Stücken von Antheren mit Pollen eher für die Hydro-, als für die Aeroherkunft der lössartigen Lehme an den erforschten Orten des europäischen Teils der UdSSR. Die Übertragung dieser Pflanzenreste durch den Wind ist unwahrscheinlich auch noch aus dem Grunde, weil nach der äolischen Hypothese die Winde entweder vom Gletscher her wehten [Tutkovskij (12)], oder aber zur Zeit der Würm-Vergletscherung dem Korridor entsprangen, der sich zwischen dem nördlichen Gletscher und dem Alpinisch-Karpatischen System gebildet hatte [Mirčink (13)]. Einleuchtend ist, dass Pollen, Sporen und Holzreste der erwähnten Baumarten aus diesen Gegenden nicht zugeträgen werden konnten.

5. Somit erhalten wir eine weitere Bekräftigung der in der Einleitung zitierten, von L. S. Berg vertretenen Hypothese über den Ursprung der lössartigen Lehme und einen Beweis dafür, dass in den untersuchten Gebieten das Material für diese Gesteinsbildung in Wasserbehältern abgelagert wurde, die aller Wahrscheinlichkeit nach wohl in Verbindung mit Gletschern standen, jedoch in der Nähe von Wäldern dahinflossen.

Für eine Lösung der Frage über die Entstehung des Lösses und der lössartigen Lehme sind die besprochenen Tatsachen natürlicherweise unzureichend, indessen ist zu erwarten, dass diese Frage, die zu den schwierigsten Problemen der Quartärgeologie gerechnet werden darf, durch weitere Studien auf dem Gebiet der Phytopaläontologie klargelegt werden wird.

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GEOCHEMISTRY

ON THE THEORY OF DESILIFICATION OF GRANITIC PEGMATITES

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In many parts of the earth crust, the veinlike bodies consisting of plagioclase, albite, corundum, tourmaline, beryl, fluorite, etc., are found only in the ultrabasic and basic rocks, rich in iron-magnesium compounds. But, unlike normal granitic pegmatites, these bodies do not contain any quartz and potassium feldspar and are regularly surrounded by contact zones of great thickness.

The first contact zone, contiguous to the vein body, consists of biotite-phlogopite or of the product of their dehydration, i. e., vermiculite. This is followed by the zone, not always constant, of actinolite-chlorite. The third and the last zone, gradually merging in the surrounding rock, is represented by talc. The other side of the vein has similar zones, disposed in the same succession, but, in case of a hanging wall, the adjacent complex of contact zones is, as a rule, of a greater thickness.

In some places, the centre of leucocratic veins is represented by normal granitic pegmatite with quartz, potassium feldspars and other minerals characteristic of the typical granite pegmatite, while the periphery of the veins, in the presence of the above-mentioned contact zones, is again represented by plagioclase, albitites, etc.

The thickness of the veinlike bodies, together with the contact zones, reaches 5—6 m and may be traced along the strike and dip for scores of metres.

The scheme on the page 190 shows these bodies and the process in question.

The theory of desilification of granitic pegmatites originated from the explanation of the genesis of such formations.

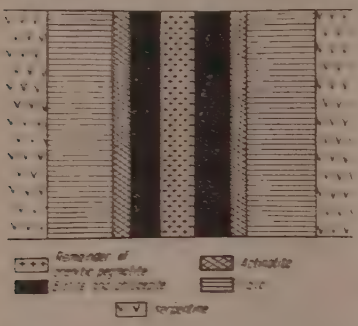
According to the theory of desilification, these bodies are the result of the mutual action of granitic pegmatites and the enclosing rocks, their centre being the remnants of granitic pegmatites altered owing to this mutual action.

According to this theory, part of pegmatite, viz. the free silicic acid—which in the normal granitic pegmatite, in the case of a «pure» line of crystallization, must have produced quartz,—the components of potassium feldspar, fluorine and other mineralizers were used in the formation of the contact mineral in which they are now actually found.

The desilification of granitic pegmatites has been studied by many investigators in different countries. Most of them start from the theory of desilification (A. Du Toit, S. Gordon, A. E. Fersman, D. S. Beliankin, P. P. Piatnickij, E. A. Kuznecov, etc.).

Other investigators (Larsen, V. N. Lodočnikov, etc.) do not accept the arguments of the adherents of this theory and believe these bodies to be the product of the postmagmatic activity of the ultrabasic and basic intrusive bodies surrounding them.

The solution of the problem of the genesis of these formations is of great importance both from the theoretical and the practical points of view, since deposits of corundum, emerald, powerful concentrations of beryl and other minerals are associated with these processes. That is why so many papers are devoted to the discussion of this problem.



The discussion is due to lack of a satisfactory solution of the principal question in the genesis of these bodies, viz. the mechanism of chemical processes occurring between the injected matter and the enclosing rock.

The explanation of the genesis of these bodies is complicated by the fact that the pegmatite melt, being a low temperature formation, is practically non-able to remelt the surrounding silicate rocks and to impart to their elements the form in which they are able to react with it directly. This explains why the same ultrabasic and basic rocks contain granite pegmatites without any contact zones: their contacts display but insignificant, chiefly thermal, effects.

Therefore, the explanation of the mechanism of chemical processes occurring between the pegmatites and the enclosing rocks, as well as of the causes of the destruction of the crystal lattice of minerals of the surrounding rocks, must be looked for in the intermediate reactions taking place between the part of the pegmatite and the enclosing rock and helping a considerable part of the pegmatite melt and the elements of the enclosing rocks to react and form chemically intermediate contact minerals.

In studying the deposits of this type, one notes the presence of a great quantity of mineralizers in them, viz., fluorine, boron, chlorine, which occur in the biotite-phlogopite and actinolite zones, in different micas, apatite, as well as in fluorite, tourmaline and other minerals. The part played by mineralizers was pointed out by all the investigators of these processes (the presence of the gaseous phase being denied neither by the adherents nor by the opponents of the desilification theory), but none of them offered a satisfactory explanation of their chemical action, and thus the chemistry of the process in question and, consequently, the genesis of these bodies remained unexplained.

The presence of water vapours in the pegmatite process, as well as the high temperatures involved, account for the fact that hydrofluoric, hydrofluoboric and other acids which are strong reagents in the silicate medium are present in the gaseous phase.

Field observations, chemical investigations of the minerals composing these bodies, experimental data, comparison and study of different deposits in various countries, as well as theoretical generalizations, lead the

author to the conclusion that the mineralizers, viz. fluorine and boron, play the principal role in the desilification of granitic pegmatites. These mineralizers pass many times the stage of hydrofluoric, hydrofluoboric and other acids and give, in association with the elements of serpentine, salts which are hardly stable at the temperature of the pegmatite process and in the presence of water vapours. These salts are hydrolyzed with the formation of the above-mentioned acids, which again act upon the surrounding rock so long as the temperature of the process allows or so long as fluorine and boron have not entered into difficultly hydrolyzable compounds (fluorite, tourmaline, alkaline haloids).

These conclusions were checked up by experiments. An aqueous solution of hydrofluosilicic acid was sealed up in a quartz tube, and the latter was heated in a steel bomb up to 250°. This resulted in an energetic corrosion of the quartz tube walls. An analysis of the reaction products showed them to contain the initial quantity of hydrofluosilicic acid as well as silicic acid formed out of the quartz tube walls.

The quantity of silicic acid was found to be proportional to the time during which the reaction proceeded and the temperature of the process. HF and $MgSiF_6$ gave analogous results. These reactions inevitably occur when hydrofluoric, hydrofluoboric and other acids act upon the surrounding rocks under conditions of interaction of the gaseous phase of granitic pegmatite with the side rocks. They destroy the crystal lattice of the minerals of the enclosing rocks and impart to the elements of which they are composed a form in which they are able to react with the pegmatite melt.

The following scheme shows the catalytic action of these acids in the natural conditions.

Scheme of Mutual Action of **HF** with Serpentine

$$a\,[\mathbf{HF}] + b\,[2SiO_2 3(Mg,\ Fe)O2H_2O] \rightleftarrows c\,[(Mg,\ Fe)SiF_6] + d\,[(Mg,\ Fe)F_2] + [A\ \text{cal}] \rightarrow$$

$$\rightarrow c\,[(Mg,\ Fe)SiF_6] + e\,[H_2O] + [B\ \text{cal}] \rightleftarrows \begin{cases} f\,[Mg,\ Fe(OH)_2 + Si(OH)_4] \\ l\,[Mg,\ F_2 + FeF_2 + SiF_4] \end{cases} + k\,[\mathbf{HF}] \rightarrow$$

$$\rightarrow \left[\begin{cases} MgF_2 \\ FeF_2 \\ SiF_4 \end{cases}\right] + q\,[H_2O] \rightleftarrows n\,[Mg(OH)_2 + Fe(OH)_2 + Si(OH)_4] + m\,[\mathbf{HF}] \rightarrow$$

Later on these are included in the contact minerals

The following molecule of serpentine

$$\rightarrow k + m = a\,[\mathbf{HF}] + b\,[2SiO_2 3(Mg,\ Fe)O2H_2O] \rightleftarrows c\,[MgSiF_6 \text{ and so on}]$$

Formation of the Contact Minerals

Hydroxides and oxides of the elements of serpentine — Oxides of the elements of pegmatite

$$a\,[Mg(OH)_2 + Fe(OH)_2 + Si(OH)_4 + H_2O] + b\,[K_2O + Al_2O_3 + SiO_2] + [HF] =$$
$$= [K_2H_2(Mg,\ Fe)_2(Al,Fe)_2Si_3O_{16} + d\,[SiO_2].$$

The biotite-phlogopite zone is formed, and so on.

Thus, the desilification of granitic pegmatites occurs only in the ultrabasic and basic rocks, because magnesium and iron form easily hydrolyzed compounds with fluorine and boron, which enables them to destroy large quantities of the enclosing rocks, even when they are present in small quantities, i. e. to play the part of catalysts.

That is why one should prospect for corundum, emerald and large concentrations of beryl in the regions of contacts of the ultrabasic and basic

rocks with comparatively young granites which had produced pegmatites containing fluorine and boron.

A detailed analysis of these processes, the chemistry of the enclosing rocks, the conditions of the formation of minerals, the geochemistry of the elements taking part in this process, as well as the effect of temperature and time, will be dealt with in a special paper on the desilification theory.

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* This work of A. E. Fersman contains a full list of literature on the theory of desilification. Lists of literature are also found in P. P. Piatnickij's and V. N. Lodočnikov's works.

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GEOCHEMISTRY

HELIUM, RADIUM AND THORIUM IN BERYLLIUM MINERALS OF THE USSR

By E. S. BURKSER, N. P. KAPUSTIN and V. V. KONDOGURY

(Communicated by V. I. Vernadsky, Member of the Academy, 27. II. 1937)

The presence of an increased helium content in beryllium minerals, especially in beryls, is a well-known fact which has so far not been satisfactorily explained. The recent investigations of Lord Rayleigh (1), who determined the content of helium in 60 specimens of beryls of different geological age, have considerably extended the experimental evidence available on the subject. Table 1 shows that the variations of the content of helium for specimens belonging to the same geological age differ widely and yet the dependence of the quantity of helium upon geological age is very clear. The older minerals are richer in helium, but show no such uniformity in the values of the content as is observable in uranium minerals of the same age if the content of helium is calculated for the same quantity of uranium.

Table 1

Content of Helium in mm^3 for 1 g of Beryl According to Rayleigh

Geological age	Archean	Paleozoic	Mezozoic	Tertiary
Maxima	77.6	16.8	2.27	0.384
Minima	6.98	1.47	0.157	0.0758

In order to determine the content of radium and thorium, 20—25 g of mineral carefully comminuted was fused with caustic soda (three times the weight of the mineral). The alloy was lixiviated with water and the undissolved part of it was treated with hydrochloric acid. The undissolved part was again fused with caustic soda and the same operation was repeated until two solutions were obtained: one alcaline and the other acid. They were poured into Curie flasks. The flasks were sealed up, and a month later the radium was determined from the emanation with a Schmidt electro-

meter. The apparatus was calibrated with a solution of the radium standard obtained from the Institute of Metrology and Standardization in Leningrad. The sensitiveness of the apparatus equals 10^{-12} g radium.

Thorium was determined in the same solutions after the emanation of radium had been removed by heating and air blowing. Through the solution heated to 70—90° a current of air was passed at a definite speed. After passing through a drying chamber with sulphuric acid, the air was admitted into an ionization chamber, the axial rod of which was connected to a sensitive electroscope with a microscopic reading of the position of the gold leaf by the observation of a thin quartz thread glued to it. The speed of the air blast was such as to produce a maximum of ionization in the ionization chamber for the same quantity of thorium. An experiment with a calibrated solution of thorium nitrate prepared from some salt bought 25—30 years ago was carried out under the same conditions. The sensitiveness of the installation is 10^{-5} g of thorium.

For the determination of helium content we selected the method of annealing pulverized mineral. The particles were of 0.03—0.06 mm as any further grinding would have resulted in a loss of helium. We used in annealing an iron tube with walls 2 mm thick. The tube was placed into a platinum resistance stove. The whole system had previously been carefully washed out with hydrogen. Then the latter was pumped out down to a pressure of 1—2 mm of the mercury column, and the annealing was conducted in a rarefied hydrogen atmosphere as, according to V. G. Khlopin, this was conducive to a complete extraction of helium. The temperature reached 1200°. The annealing lasted $1^1/_2$—2 hours. The gases obtained were transferred by a mercury pump into a vessel with quicksilver. They were freed from steam, oxygen, hydrogen and carbodioxide by washing with an alcaline pyrogallic acid solution and passing over incandescent copp er oxide, soda lime and phosphoric anhydride. The residual gas consisting of nitrogen and rare gases, after its volume had been measured, was introduced into an apparatus for determining helium as designed by V. G. Khlopin and A. N. Lukashuk and slightly modified by our Institute. The nitrogen was absorbed by activated coal at liquid air temperature, the process lasting $1^1/_2$—2 hours. To check the purity of helium, the spectrum of the unabsorbed part of helium and neon was examined. No neon lines were observed. If no other lines but those of helium were present in the spectrum, the gas was introduced into a capillary measuring burette where its volume was determined at lowered pressures, of about 40 to 60 mm of the mercury column. Each division of the burette took up a volume of $0.8 \cdot 10^{-3}$ mm. The results of the measurements of radium, thorium and helium content are given in Table 2. Taking for granted that the liberated nitrogen was of atmospheric origin we corrected the amount of helium obtained by measurement for atmospheric helium and neon content, calculated according to the nitrogen present in the gases. The absence of neon lines in the helium spectrum may be due to the low concentration of neon.

The grinding of beryl to a size of 0.03 mm produced a large yield of helium. Therefore we considered the amount of helium obtained through grinding to a size of 0.03 mm to represent the helium content of the mineral.

The content of radium in beryllium minerals is less than in massive rocks, whereas the content of thorium is in some specimens practically the same. If we assume all the investigated minerals to be of Pre-Cambrian origin and their age to be at most 2 milliard years, it will be easy to calculate the excess of helium in the investigated minerals that was produced by unknown pro-

Table 2

Nos of samples	Name of mineral	Weight in grams for helium determination	Quantity of nitrogen separated together with rare gases, in mm³	Quantity of helium determined by direct measurement, mm	Quantity of helium minus helium and neon of atmospheric origin, mm	Quantity of helium in mm³ per 1 g of mineral		Quantity of radium in g per 1 g of mineral $\times 10^{12}$	Quantity of thorium in g per 1 g of mineral $\times 10^{6}$
						Size of grain 0,06 mm.	Size of grain 0,03 mm.		
1	Transparent beryl . .	1.9560	3.8	9.49	9.38	2.60	4.80	0.04	Not discov.
2	Yellow beryl	2.3270	4.2	3.37	3.25	1.10	1.46	0.02	2.00
3	Green beryl	1.2260	3.8	3.66	3.55	2.30	2.90	0.14	0.60
4	Green beryl	1.0752	2.1	1.66	1.51	1.20	1.50	0.10	0.20
5	Alexandrite	1.5003	2.6	3.22	3.15	1.50	2.10	0.18	2.20
6	Phenacite	4.0736	3.6	10.79	10.69	2.00	2.62	0.26	1.70
7	Beryl, sample No 1 . .	2.6670	3.4	38.97	38.87	15.40	17.20	0.62	Not discov.
8	Beryl, sample No 2 . .	4.4044	2.8	10.23	10.13	1.80	2.30	0.09	Not discov.

Table 3

Nos	Name of the mineral	Quantity of helium accumulated in 1 g of mineral as the result of disintegration of the elements of uranium and thorium series, in mm³, for 2.10^9 years	Quantity of helium accumulated in 1 g of mineral as the result of unknown processes of the disintegration of atoms, in mm³
1	Beryl	0.29	4.51
2	»	0.93	0.53
3	»	0.37	2.53
4	»	0.16	1.34
5	Alexandrite	1.12	0.98
6	Phenacite	0.92	1.77
7	Beryl	0.43	16.77
8	»	0.064	2.24

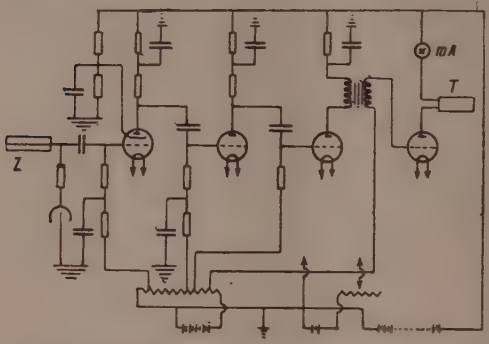
cesses, unconnected with the disintegration of uranium, radium and thorium atoms.

The results of this calculation are given in Table 3.

An accumulation of helium of unknown origin has been found to exist in nearly all the minerals under consideration.

Calculating the content of beryllium from the chemical formulae of the minerals enumerated [beryl $3BeO.Al_2O_3.6SiO_2$, alexandrite $Be(AlO_2)_2$, phenacite Be_2SiO_4] we obtain 4.1%, 7.1% and 16.4% respectively.

If the formation of helium is connected with atoms of beryllium one should expect for the same deposit an accumulation of helium the greater, the higher the beryllium content in the minerals.



Amplifying scheme for the Geiger-Müller counter; z counter, t mechanical recorder; the circuit of the first valve is screened.

For a comparison we select three specimens: beryl № 2, chrysoberyl and phenacite containing about the same quantity of radioelements, and estimate them jointly according to their ability for helium formation. These specimens were notable for their purity. The ratio between helium content in mm^3 and beryllium content in grams in 100 g of mineral was 12.92 for beryl № 2, 13.8 for alexandrite and 10.77 for phenacite. The similarity of these ratios for different minerals suggests beryllium atoms as a source of helium. They may either possess a weak alpha radiation themselves or disintegrate discharging alpha particles under the influence of external factors.

The former is out of the question, since there is no obvious dependence between the age of the beryllium mineral and the quantity of accumulated helium, which, according to the data of Lord Rayleigh's work, ought certainly be the case if beryllium possessed a constant radio-activity, however a weak one.

A number of attempts were made to detect alpha-radiation in beryllium. In 1933 Langer and Raitt [2] discovered ionization due to the alpha rays of beryllium, which was decreased by 40% by aluminium foil one micron thick. This information induced Evans and Henderson to carry out control experiments in order to settle the question of beryllium radio-activity [3]. They used an ionization chamber and an amplifying circuit. The experiment gave negative results. The authors did not find any alpha particles. The radio-activity of beryllium was subsequently examined by Hans. Harkins and others, always with the same negative result. In order to settle the question of alpha radiation in beryllium, we experimented with chemically pure beryllium carbonate. We used three methods: a Geiger counter, the scintillation method and the photographic method.

The recording apparatus in the counter method consisted of a Geiger-Müller counter connected with a four-valve amplifying circuit (figure). Along the axis of the counter was stretched an oxydized steel wire 0.1 mm in diameter. The number of spontaneous discharges with a potential of 1050 volt was 3.8 a minute. In these investigations a preparation of beryl-

lium was used. On adding up, an average of 4.1 discharges per minute was found, whereas, according to the data of Langer and Raitt, there ought to have been about 2.9 discharges a minute over and above the spontaneous ones.

At the same time the presence of alpha particles was investigated by the photographic method. Grains of U_3O_8 and of beryllium carbonate were put at fixed places of the sensitized coating of a photographic plate. In different experiments the exposure was from 15 to 30 days. As a result the photoplate showed blackenings due to uranium oxyde but not a trace of beryllium carbonate. Finally, the method of scintillations was used. In this case, too, the experiment gave a negative result.

Now, if beryllium itself is not a radioactive element, its disintegration, due to gamma radiation, may possibly produce alpha particles. The disintegration of beryllium atoms under the influence of alpha radiation follows the equation:

$$Be_4^9 + He_2^4 \rightarrow C_6^{12} + n_0' .$$

Szillard and Chalmers ([4]) showed that under the influence of gamma rays beryllium atoms discharge neutrons following the equation:

$$Be_4^9 + \gamma \rightarrow Be_4^8 + n_0' .$$

If the isotope Be_4^8 is not stable, it can disintegrate following the equation:

$$Be_4^8 \rightarrow 2He_2^4 .$$

O. Hahn ([5]) takes this for granted in order to explain the accumulation of helium in beryls. So does H. I. Born ([6]), adding that the extent of helium accumulation depends on the radioactivity of the surrounding rocks, on the action of the permeating radiation and on geological age.

But it is necessary to mention that the attempts of G. Bernardini and M. Mando ([7]) to call forth alpha radiation in beryllium by the direct action of mesothorium gamma rays gave a negative result. The authors consider the atoms Be_4^8 to be stable enough. According to U. Crane and C. C. Lauristen ([8]) the mass of Be_4^9—9.0125 nearly equals the sum of the masses $2He_2^4 + n_0^1$; therefore the disintegration of Be_4^9 atoms requires gamma rays possessing an energy of about $1.4 \cdot 10^{-6}$ eV.

The disintegration of the same atom and the formation of two alpha particles from Be_4^8 demands an energy of about $2.0 \cdot 10^{-6}$ eV, according to the calculations of these authors. There are in the gamma radiation of radium and thorium certain components possessing an energy of more than $2.0 \cdot 10^{-6}$ eV.

Further experiments upon the action of gamma rays with an energy of $2.0 \cdot 10^{-6}$ eV upon beryllium preparations, combined with a simultaneous observation of the discharge of alpha particles and the formation of helium must solve the question of the correctness of Hahn's and Born's conjecture that helium originates in beryllium minerals.

Conclusions

1. The soviet beryl minerals from emerald mines and the mines of Mariupol region contain helium in quantities surpassing any possible accumulation due to the disintegration of atoms of the radioactive elements present in the minerals.

2. The ratios of excess helium $\frac{\text{He mm}^3}{\text{Be g}}$ for three different beryllium minerals of the same deposit, possessing radioelements of nearly the same capacity for helium formation but with a different beryllium content, are practically the same.

3. The specimens of beryllium investigated with a Geiger-Müller counter, by the scintillation method, and by the photographic method have shown no alpha radiation.

4. The formation of helium in beryllium minerals must be due to the decay of beryllium atoms under the influence of gamma radiations both of the radio-active elements contained in the minerals themselves and of those acting from outside.

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BIOCHEMIE

ÜBER DEN EINFLUSS VON KOLLOIDEN UND VON ELEKTROLYTEN AUF DEN GLEICHGEWICHTSZUSTAND BEI MALTOSEWIRKUNG

Von D. MICHLIN und P. KOLESNIKOV

(Vorgelegt von A. N. Bach, Mitglied der Akademie, d. 16. III. 1937)

Die Bedeutung der kolloidalen Erscheinungen für die Gleichgewichtszustände bei reversiblen fermentativen Reaktionen scheint unterschätzt worden zu sein. Die Wirkungen von Elektrolyten auf Fermente werden oft bloss vom Standpunkt ihrer «Giftigkeit» oder Beschleunigungsfähigkeit angesehen, ohne dabei die kolloidalen Erscheinungen, die allein für solche «Hemmungen» und «Beschleunigungen» verantwortlich sind, zu beachten. Besonders kann man dies bei Erforschung der enzymatischen Synthese beobachten. In der lebenden Zelle ist aber die Möglichkeit der Synthese selbst durch Oberflächenerscheinungen bedingt, die als Hauptquelle der dazu erforderlichen Energie dienen. Michlin und Fetissowa [1] konnten zeigen, wie weit die Bildung von Lactose in der Milchdrüse von dem Zustand der Gewebskolloide abhängig ist. In dieser Arbeit werden ähnliche Gleichgewichtsuntersuchungen mit Hefemaltase angeführt. Es war im voraus zu erwarten, dass im Falle des Hefenautolysats und besonders mit gereinigten Fermentpräparaten die Beziehungen sich etwa anders erweisen könnten als bei Drüsebrei.

Im Gegensatz zu Lactose, die in dem Gewebe von selbst hydrolisiert wird, stabilisieren sich die neugebildeten Disaccharide bei der Synthese von Maltose. Das Ausmass der Synthese ist aber auch hier von der Anwesenheit der Kolloide und von ihrem Zustand sehr abhängig. Schon bei Zugabe kleiner Mengen Eiweisslösung nimmt die Menge des synthetisierten Zuckers um 20—30% zu. Eine ausgeprägte Verschiebung des Gleichgewichts wird durch Salze erzeugt. Besonders fördernd wirken Sulfate auf die Synthese. Und umgekehrt hemmt das Ammoniumrhodanid die Synthese bis zu Null. Bekanntlich ist das erste Salz durch seine entquellende Wirkung, das zweite durch seine peptisierende Fähigkeit ausgezeichnet.

Der Einfluss der anderen Salze ist geringer.

Dass die Wirkung der Elektrolyte auf das Gleichgewicht eine rein kolloidale Erscheinung ist, folgt daraus, dass dieser Einfluss bei gereinigten Präparaten der Maltase fehlt. Eine Verschiebung des Gleichgewichts bei der nach Willstätter gereinigten Maltase kommt nur, nachdem Eieralbumin oder Gelatine zugegeben ist, vor. Erst dann üben die Salze ihre förderende Wirkung auf die Synthese aus.

Die meisten Angaben über die Wirkungen von verschiedenen Salzen auf die Fermenttätigkeit wären nur dann von physiologischem Werte, wenn

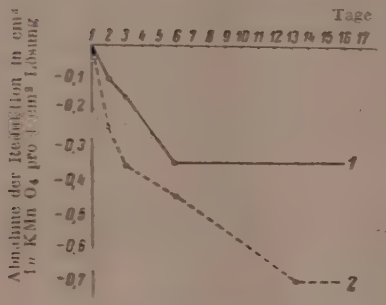

Abb. 1. Wirkung der Kolloide auf die Synthese von Maltase. *1* Kontrolle, *2* + Eieralbumin.

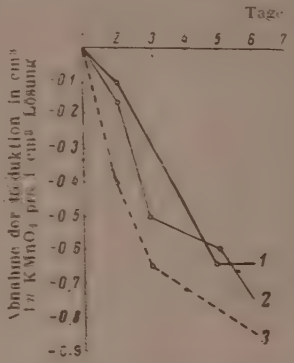

Abb. 2. Einfluss der Kolloide auf die Wirkung der gereinigten Maltase. *1* Kontrolle. *2* + Eieralbumin. *3* + Gelatine.

sie im Lichte der kolloid-chemischen Gesetzmässigkeiten betrachtet werden könnten.

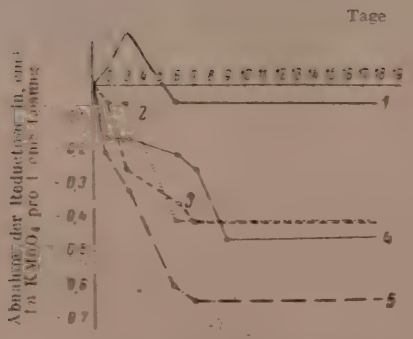

Abb. 3. Einfluss der Salze auf die synthetische Wirkung des Hefeautolysats. *1* NH_4CNS, *2* NaCl, *3* Kontrolle. *4* NaF. *5* K_2SO_4.

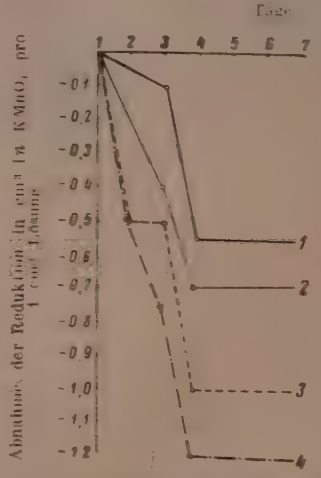

Abb. 4. Einfluss der Kolloide und Salze auf die Wirkung der gereinigten Maltase. *1* + Gelatine + NH_4CNS. *2* Kontrolle. *3* + Gelatine. *4* + Gelatine + Na_2SO_4.

Diese Wirkungen von Elektrolyten müssen sich auf den Zustand des Gleichgewichts beziehen, der in dem sehr komplizierten Milieu der Fermentreaktionen solchen Verschiebungen unterliegt, die bei der homogenen Katalyse unbekannt sind.

METHODISCHES

Trockenpräparate und Lösungen der Hefemaltose wurden nach Croft Hill (²) hergestellt.

Für synthetische Versuche wurden 60%-ige Lösungen von Glucose verwendet. Die Mischung wurde aus 20 cm³ Glucoselösung und 10 cm³ Hefeautolysat oder Suspension bei Zugabe 3 cm³ Toluol zusammengestellt.

Von dieser Mischung wurde täglich 1 cm³ genommen, welcher durch 19 cm³ Wasser verdünnt, zur Reduktionsbestimmung nach Bertrandt kommt.

Über den Verlauf der Synthese wurde aus dem Abfall der Reduktion geurteilt, die infolge Sauerhydrolyse bis zur anfänglichen Höhe wieder steigt. Zur Prüfung kamen 2%-ige Lösungen von Eiweiss, die in Mengen von 1 cm³ hinzugefügt wurden, und einige Salze: Natriumchlorid, Jodide, Sulfate und Rhodanide. Einige von den gesamten, eindeutigen Ergebnissen werden hier in Form von Kurven angeführt.

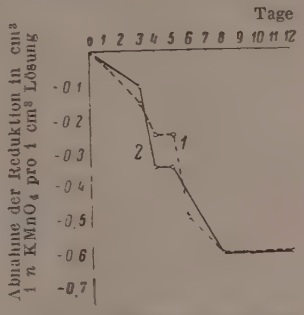

Abb. 5. Wirkung der Salze auf gereinigte Maltase. *1* Na_2SO_4. *2* Kontrolle.

Die Frage nach der Einheitlichkeit des synthetisierten Zuckers ist von uns nicht berührt worden. Die Entstehung von Maltose in den Syntheseversuchen ist von Pringsheim und Leibowitz (³) festgestellt worden. Für unseren Zweck ist die Natur der neben der Maltose gebildeten Disaccharide belanglos.

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Eingegangen
d. 16. III. 1937.

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BIOCHEMISTRY

SOME DATA ON THE YIELD OF ESSENTIAL OIL BY A NEW VARIETY OF DRAGONHEAD

(*DRACOCEPHALUM MOLDAVICA* L. v. *HEXAGONUM* D. VAKULIN) FROM DIFFERENT SEED-SAMPLES

By D. J. VAKULIN

(Communicated by A. A. Richter, Member of the Academy, 16.III.1937)

During our examination of the specimens of the new variety of the dragonhead with a hexagonal stem (*Dracocephalum Moldavica* L. v. *hexagonum* D. Vakulin) (1), received from scientific institutions and industrial organizations of the USSR and from abroad, we discovered that, in addition to other characters, this variety differs in its yield of essential oil.

We could not find in the literature any mention of the variety in question (v. *hexagonum* D. Vak.), nor any data on the content of essential oil, on the correlation between this content and variations in the stems, etc.

At our request, the Chemical Laboratory of the Odessa Botanical Gardens made experimental determinations of the yield of essential oil by dragonhead plants showing variations in stem form, mainly by v. *hexagonum* D. Vak.

For purposes of comparison with the hexagonal-stemmed variety of the dragonhead (v. *hexagonum*), distillations were also made from specimens of the common square-stemmed dragonhead.

The following table shows the results.

Serial No	Place of origin	Shape	Yield of essential oil in percentages of dry weight	State of plant on date of distillation
79	Vilna	Common square-stemmed dragonhead .	0.133	Fading
79	»	Hexagonal variety (v. *hexagonum* D. Vak.)	0.196	»
79	»	Hexagonal variety (v. *hexagonum* D. Vak.)	0.390	Full bloom
83	Prague	Common square-stemmed dragonhead .	0.273	» »
83	»	Hexagonal variety (v. *hexagonum* D. Vak.)	0.313	» »
91	Gorki	Common square-stemmed dragonhead .	0.316	» »
91	»	Hexagonal variety (v. *hexagonum* D. Vak.)	0.627	» »

These scanty data are most interesting, for the table shows that in all cases the hexagonal-stemmed dragonhead gave a higher yield of essential oil than the corresponding common square-stemmed plant. This difference is especially marked in the plants with white flowers received from Gorki (the other plants included in the above table had blue flower). The hexagonal-stemmed variety from Gorki yielded twice as much volatile oil (0.627%) as the common square-stemmed dragonhead (0.316%). The hexagonal-stemmed variety from Prague also yielded more volatile oil than the corresponding square-stemmed plants. All the above plants from Gorki and Prague were distilled in the third decade of July, when in full bloom; as for the plants from Vilna, part of the specimens of the hexagonal-stemmed variety was distilled when in full bloom, while the other part of them and all the square-stemmed specimens were distilled in a fading condition. The results obtained were identical and very characteristical; at the stage of fading, the hexagonal-stemmed variety also yielded more essential oil than the common square-stemmed dragonheads.

The fact that the hexagonal-stemmed variety of the dragonhead showed a higher yield of essential oil than the common square-stemmed plants, not only when in full bloom but also at the stage of fading, justifies the assumption that these are not chance figures. They point to a very interesting correlation, and in any case, they justify further studies on *Dracocephalum Moldavica* L. v. *hexagonum* D. Vak.

As regards the frequency of occurrence of this variety, a careful examination of plants grown from different seed-samples received from various countries of Western Europe and from various localities of the USSR has shown us that the hexagonal-stemmed variety does not occur in all the samples. Its frequency in the different samples ranged from 1 to 16 specimens. This would seem to show that the variety under consideration does not occur everywhere and that the percentage of the variety in the different samples varies a great deal.

Passing to a discussion of the probable causes of this phenomenon, we advance the conjecture that the new variety (v. *hexagonum* D. Vak.) is associated with definite localities and with definite climatic conditions.

Unfortunately, we have no complete collection of seed samples of dragonheads at our disposal. But, if we examine the distribution of those localities in the samples from which the new variety has been recorded, it appears possible to associate the occurrence of this variety with definite areas. The Ukraine would seem to be the first to attract our attention, for here the new variety was present in all the samples in more or less considerable quantities. The adjacent areas (Czechoslovakia, Poland, White Russia, etc.) seem to tend towards the Ukraine. In support of this conjecture we must note that some of these areas have shown a new variety, not only of *D. Moldavica* L., but also of *D. argunense*. In some of the samples from these localities, specimens with octagonal stems have been found, while no variations in the form of the stem have been observed in any of the more northern samples.

If the above conjecture is confirmed, we shall then probably have in the Ukraine and the adjacent areas one of the centres of the origin of stem-variations of dragonheads. It should also be noted that the number of specimens with hexagonal stems appears to increase eastward.

We have no data as yet on the total yield of volatile oil by the hexagonal-stemmed shrub, but it is to be expected à priori that, since the hexagonal-

stemmed variety* has a larger number of branches, it must have a greater number of leaves and, in general, a greater mass of foliage, i. e., it must give a higher yield, inasmuch as the foliage contains the essential oil.

Therefore, it would seem that the hexagonal-stemmed *Dracocephalum Moldavica* L. v. *hexagonum* D. Vak. possesses a favourable combination of such important properties as a higher content of essential oil and a greater yield of green mass, as compared with the common square-stemmed dragonhead.

Further work on the problem is being done.

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* The square-stemmed dragonheads have, on an average, six nodes on their stem with two branches to each, i. e., in all 12 branches, while the hexagonal-stemmed variety has three branches to each node, i. e., 18 branches per bush.

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GENETICS

MORPHOLOGY OF THE CHROMOSOMES OF SOME SPECIES OF POTATO

By E. M. ŠEPELEVA

(Communicated by N. I. Vavilov, Member of the Academy, 17. III. 1937)

The chromosomes of the potato are rather small and difficult to study. With the aim of bringing out more clearly the individuality of the chromosomes, the preparations were fixed with the «Platinik Formalin weak» of

Fig. 1.

Fig. 2.

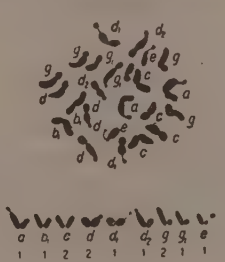

Fig. 3.

Lewitsky (1), which gave quite good results and made it possible to establish idiograms for several species.

The investigation was begun with the 24-chromosome ($2n$) species of the section *Tuberarium*.

In the subsection *Pinnatisecta* two species were investigated: one from the group *Commersoniana*, viz. *Solanum Henryi* Buk. et Lechn. (Fig. 1) and one from the group *Glabrescentia*, viz. *S. subtilius* aff. (Fig. 2). In the subsection *Tuberosa* four species were investigated: one from the group *Vaviloviana*, viz. *S. Vavilovii* Juz. et Buk. (Fig. 3) and three from the group *Andigena*, viz. *S. ajanhuiri* Juz. et Buk. (Fig. 4), *S. goniocalyx* Juz. et Buk. (Fig. 5) and *S. Kesselbrenneri* Juz. et Buk. (Fig. 6).

From our idiograms it is clear that the species investigated have the same types of chromosomes, but that the number of chromosomes of each type differs in the various species and some of the types are entirely lacking in some species. A description of the chromosomes by types follows.

Type *a*. Large chromosomes with very unequal arms and with a secondary constriction near the end of the longer arm. In some species, such as *S. Henryi* and *S. goniocalyx*, this appendage has the form of a small head,

while in others it is more elongated, narrow at the point of constriction and broadening toward the other end. The latter type is most clearly seen in *S. ajanhuiri*, but this species has two other pairs of chromosomes with a small head on the long arm (a_1), resembling very much similar chromosomes in *S. Henryi* and *S. goniocalyx*.

Type *b*. Unequal-armed chromosomes which may be subdivided into two groups: (b) large chromosomes with very unequal arms and (b_1) small chromosomes with only a slight difference in length of arms. The first type is found only in three species: one pair in *S. goniocalyx* and *S. Kesselbrenneri* and two pairs in *S. Henryi*. The second type is encountered in varying numbers in almost all the species: one pair in *S. Vavilovii*, *S. ajanhuiri*, *S. goniocalyx* and *S. Kesselbrenneri* and two pairs in *S. Henryi*. In *S. subtilius* aff. unequal-armed chromosomes (of the type *b* and b_1) are not found at all.

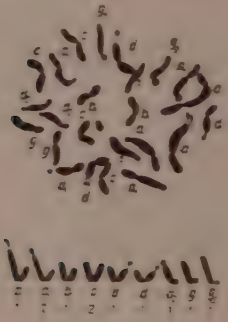

Fig. 4.

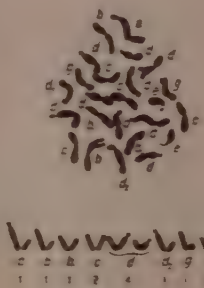

Fig. 5.

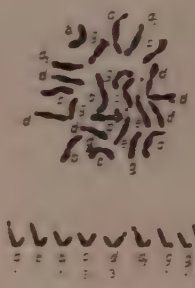

Fig. 6.

Type *c*. Equal-armed chromosomes. In all the species there are two pairs of such chromosomes. In *S. Vavilovii*, *S. ajanhuiri*, *S. goniocalyx*, and *S. Kesselbrenneri* both pairs are of the same size, while in *S. Henryi* and *S. subtilius* aff. one pair is smaller and the chromosomes are bisquit-like in shape.

Type *d*. Small chromosomes having secondary constrictions which may be subdivided into several groups: (d_2) unequal-armed chromosomes with a small head on the long arm, one pair found in each species; and (d, d_1) equal-armed chromosomes differing in size and having either a small head or a satellite. *S. Henryi* has no chromosomes of this type. *S. subtilius* aff. has three pairs with small heads and two pairs of bisquit-shaped chromosomes with satellites; *S. Vavilovii* has two pairs with small heads and one with satellites: *S. ajanhuiri* has two pairs, unequal in size, with satellites: *S. goniocalyx* has four pairs with small heads: and *S. Kesselbrenneri* has three pairs with small heads.

Type *g*. Chromosomes having no secondary constriction and one arm as short as a small head. Such chromosomes were found in all the investigated species but in different numbers: two pairs in *S. subtilius*, *S. Kesselbrenneri*, and *S. ajanhuiri*: one pair in *S. goniocalyx*, and three pairs in *S. Henryi* and *S. Vavilovii*. In *S. Henryi* one of the three pairs consists of longer chromosomes with very small heads.

Type *e*. Satellited chromosomes with one arm as short as a small head. These are found in all the species except *S. ajanhuiri*. In *S. Vavilovii* and *S. goniocalyx* these chromosomes are very small and differ sharply from all the rest.

The chromosomes of *S. ajanhuiri* and *S. phureja* (no figure is given of the latter species) are considerably larger than those of the other species, and in almost all the investigated plates there was observed a twenty-fifth element in the form of a fragment, which was usually situated near the same chromosome (*c*), but which could not be seen to have any direct link with this chromosome. A similar fragment was found in *S. Vavilovii*. In potato root-tips plates are often encountered with double the usual number of chromosomes. In such a plate of *S. ajanhuiri* there were two fragments.

A comparison of the idiograms shows that all the investigated species differ in the presence or absence of one or another type of chromosomes and in the number of pairs of each type.

Fig. 7.

In addition to the species described, there was investigated one 48-chromosome species of *S. tuberosum. Great Scott* (Fig. 7.). The idiogram given here cannot be considered final, since it was not possible, in the case of every chromosome, to bring out the constrictions with sufficient clarity. Only twenty-one of the pairs may be considered as more or less accurately determined: two pairs of large, unequal-armed chromosomes with a secondary constriction on the longer arm (type *a*), represented by a single pair in all the 24-chromosome species; one pair of large, unequal-armed chromosomes (type *b*); five pairs of equal-armed chromosomes (type *c*); four pairs of equal-armed chromosomes with small heads (type *d*); one pair of bisquit-shaped chromosomes with satellites (type d_1); one pair of unequal-armed chromosomes with a small head on the longer arm (type d_2); and seven pairs of «headed» chromosomes (types *g* and g_1).

From the above description of the chromosomes of *S. tuberosum* it is clear that they comprise the same types of chromosomes as were described for the 24-chromosome forms, but that there are a larger number of chromosomes of each type.

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PLANT PHYSIOLOGY

PHOTOPERIODISM AND A HYPOTHESIS AS TO HORMONES OF FLOWERING

By B. S. MOŠKOV

(Communicated by N. I. Vavilov, Member of the Academy, 25.III.1937)

Photoperiodism constitutes undoubtedly one of the most important discoveries made in biology during the present century. Even now it is difficult to estimate all the possibilities of the new investigations which have arisen as a result of the discoveries of Garner and Allard. Photoperiodic action has become one of the most efficient methods in the study of the life processes of plants.

In an attempt to get to the essence of the phenomenon in question our investigations have revealed the role of leaves in the reception of photoperiodic conditions ([1], [2]). They have shown that it is precisely the leaf—and not the entire green plant or its apex, as was assumed by Garner and Allard ([3]), Knott ([4]), and Razumov ([5])—which constitutes the organ wherein occur the first physiological changes which induce this or that photoperiodic reaction. The correctness of our hypothesis has been confirmed by the investigations of Psarev ([6]) and Čajlachjan ([7]).

Starting from the hypotheis that the leaves play an important role in photoperiodic reaction, it was natural to think of using grafts for answering the following questions: 1) Are the flower-producing substances synthesized by short-day and long-day plants identical? 2) In what manner are such substances translocated in plants? 3) Is it possible by means of grafts to transfer flower-producing substances from one graft component to the other?

The plant chosen for these investigations was *Nicotiana*. As is known, most species of *Nicotiana* flower under conditions of a long day and can flower under continuous light. But there are forms which flower only under conditions of a short day. Such a short-day form is *Nicotiana tabacum*, variety Maryland Mammoth, which was found by Dr. Garner and which served him and Dr. Allard as the plant through which they discovered photoperiodism.

Our preliminary experiments established that Maryland Mammoth forms flower buds only under a length of day of from 6 to 12 hours. Under conditions of a longer day it does not form flower buds at all. In the fall of 1935 we grafted a *Nicotiana rustica* top on five-month-old Mammoth plants. All the plants were grown under continuous light, where Mammoth cannot flower. Most of the grafts failed. Only five Mammoth plants upon which

N. rustica tops had been grafted survived. Two of these plants produced flower buds on their side branches.

In 1936 this experiment was considerably extended. As in the experiment of the previous year, Maryland Mammoth plants growing under continuous light (natural illumination by day; electric light by night) were taken as stocks. As scions we used the variety Samsun, which flowers under conditions of continuous light. Two kinds of grafts were made — splice and cleft grafts — when the Mammoth plants had reached a height of 50—70 cm.

When splice-grafting was used, the tops of the Mammoth plants were cut off in a slanting direction, and tops of Samsun plants, — 25—30 cm long and with five or six fully developed leaves — cut off at the same angle were bound to the stock with raffia. The tip of the scion was immersed in a flask containing water. In this way the scion was supplied with water during the first five to ten days, thus insuring the restoration of the turgor of its leaves by the second or third day after grafting.

When a cleft graft was made, after the top of a Mammoth plant had been cut off, the stock was split to a depth of 3 cm, and into the cleft there were inserted tips from Samsun plants 3—5 cm long with a cluster of unfolded leaflets. The place of the graft was similarly bound with raffia.

As controls we used Mammoth plants, growing under the same conditions as the grafted ones: a) without undergoing any surgical operation; b) with their tops cut off; and c) with grafted tops taken from other Mammoth plants growing under the same conditions. The last group served to control the operation of grafting itself. In each group there were from 10 to 30 plants.

Only those Mammoth plants flowered on the tops of which the long Samsun tops had been spliced. From these plants on the fifth day after grafting the upper leaves were removed from the stock. From the axils of these removed leaves sprang side shoots, which formed flower buds as a result of the effect produced on them by the leaves of the Samsun scion. In this group all the plants flowered, while not a single plant flowered in any of the other groups. Thus, it may be considered established that a flower-producing substance passed from the leaves of the Samsun scion to the side shoots of the Mammoth stock and induced these shoots to flower under conditions of continuous light.

The question arises: Why did not the cleft-grafted Mammoth plants bear flowers? Here two explanations are possible.

First, it may have been due to the difference in number of leaves on the scion at the time the graft was made. It is possible that in the case of the cleft graft the leaves of the scion, not appearing in sufficient quantity until considerably later than in the case of the splice graft, could not synthesize these substances because of changed temperature conditions.

The second, and more probable, explanation is based on differences in the manner in which the graft components grew together. When the splice graft was made, the union was comparatively weak and only of external parts, while in the case of the cleft graft the union was much stronger but irregular, owing to the formation of a large mass of new tissues causing a swelling in the stalk. It is possible that in the latter case the phloem tissues did not coincide, and this hampered the transfer of the flower-producing substances from the scion to the stock. This assumption is confirmed by investigations on the growth hormone, which show that the latter is conveyed through the exterior tissues.

The idea of inducing plants which do not flower under ordinary conditions to flower by means of grafting is not new. But usually it was the stock which produced an effect upon the scion. Most of the positive results from such grafts have been attributed by Krenke ([8]) and other investigators not only to the action of the roots of the stock on the scion but also to the irregularity of the union of the graft components. The latter breaks the normal interrelation between root and air nutrition of the scion and thereby induces it to flower. Hence, the results of Čajlachjan's grafts cannot serve as a direct confirmation of our data.

The flowering of the Jerusalem artichoke when grafted on the sunflower, observed by many investigators, particularly in the USSR by Gorškov ([10]) and Škrebtienko ([11]), has been attributed chiefly to changes induced by the grafting itself. To use a graft of Jerusalem artichoke on itself as a control for such experimental grafts, as Čajlachjan did, is not possible since in this case the union of the graft components (of one and the same species) may be entirely different from that of a stock and scion of two different species. As regards the grafts made by Čajlachjan of perilla on perilla, such results can also be obtained without any grafting, so that they are not pertinent here.

The role of leaves in the interrelations between stock and scion has remained unelucidated in most papers. Only a very few writers have touched upon the rôle of leaves in the interaction of the graft components. I. V. Mičurin alone stressed this point with particular persistence.

Our grafts are distinguished from all others by the fact that they serve as proof of the transfer of flower-producing substances from the leaves of the scion to the side shoots of the stock, when the latter is grown under conditions making its flowering impossible. Before our experiments such grafts had not been made. On the basis of the results obtained from them the following conclusions may be drawn:

1. The flower-producing substance, which, prior to its isolation, can only provisionally be considered a flower-producing hormone, is synthesized by the leaves of mature plants which have previously passed through all the necessary stages in their development.

2. The leaves of some so-called «short-day» species synthesize this substance only under conditions of definite, optimum photoperiods, while leaves of other species synthesize it also under continuous illumination.

3. Flowering of varieties differing in their photoperiodic reaction is conditioned by one and the same flower-producing substance, irrespective of whether it is synthesized by leaves of a short-day or long-day variety.

4. Consequently, leaves of short-day plants under conditions of a short day and of long-day plants under conditions of a long day synthesize one and the same flower-producing substance.

5. In order that this flower-producing substance be transferred from the scion to the stock, a very weak union of their external tissues is sufficient. Hence, it may be assumed that this substance is conveyed within the plant not by the usual channels but directly from cell to cell by osmotic processes.

6. Utilizing the flower-producing substance of mature plants by different kinds of grafts and various injections, one can rely on success in accelerating the flowering of seedlings of woody species.

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PLANT PHYSIOLOGY

NEW FACTS IN SUPPORT OF THE HORMONAL THEORY OF PLANT DEVELOPMENT. II

By M. Ch. ČAJLACHJAN and L. M. YARKOVAJA

(Communicated by A. A. Richter, Member of the Academy, 11. IV. 1937)

The three previous works of Čajlachjan, ([1, 2, 3]) presented facts serving as a basis for advancing conclusions as to the hormonal nature of the process of plant development. One of these facts finds expression in the establishment that the surface area responding to photoperiodic influence is in the leaves and that the processes arising therefrom in the leaf tissues govern the blossoming development of the plant.

Similar conclusions as to the primary importance of the leaves in photoperiodic reactions also were arrived at by Moshkov ([4,5]) in his work with chrysantemum. Though in the experiments of Moshkov bud formation and not blossoming, was accepted as indicative of the photoperiodic reaction, they bear indications pointing to the fact that the photoperiodic impulse was responded to by the leaves. Material confirming this conclusion is presented in a short article by Psarev working on soya ([6]).

Details were given, in one of the works previously mentioned ([3]), regarding transplantation tests on *Perilla*, sunflower and *Helianthus tuberosus* indicating that the blossoming hormone or florigen is capable of passing from one plant to another via the grafting point and possesses the same nature in different plants.

Tests in grafting *Helianthus tuberosus* on to sunflower showed that the blossoming of the short-day plant, *Helianthus tuberosus*, took place under the influence of the hormone formed in the leaves of the sunflower plant on a long day.

In tests with *Perilla*, following grafting, hormone formation was induced in one of the stocks resulting in a flow hormones from this stock to the hormoneless scion.

Other transplantation tests with *Perilla* were conducted so that prior to grafting an accumulation of hormones was brought about in the stock plant and vegetating tops were grafted thereto.

Following the appearance of seedlings of *Perilla nankinensis* sowed on March 4th, 1936, the plants were exposed to continuous light until April 23rd and up till May 20th to full natural daylight. From May 20th part of the plants were transferred to conditions of a short 10 hour day the other part remaining exposed to the full day. Under the influence of the short day the *Perilla* showed signs of formation of fruit shoots by June 13th and, on the

19th idem the stocks began to flower. The stocks exposed to the full day remained in a vegetative condition, which was to be expected, as in the latitude of Moscow *Perilla* never blooms in the summer months.

The tops of these full day vegetating stocks were grafted to the blossoming. short day plant. The grafting was made on May 19th, by wedge in split. the tops being preliminarily stripped. Simultaneously, control grafting was carried out of vegetating tops to vegetating full day stocks. All the leaves were stripped from the tops with the exception of two small leaves at the growing point. All the side off-shoots were stripped from the experimental and control graft stocks on the day of the operation,—blossoming from the experimentals, and vegetative from the controls,—in order to ensure that the hormones accumulated in the leaves of the short day stock should not be utilised by the shoots. For ten days following the operation, the plants were kept in a humid chamber and were then transferred to a greenhouse. Both in the humid chamber and all the rest of the time the test and control graftings were exposed to a full day so that the grafted tops were at no time under the influence of a short day.

As all the off-shoots were stripped from all the stocks the test graftings could not be outwardly distinguished from the controls: only the leaves remained on the stocks. However, the physiological condition of the leaves made itself evident: after a period of time blossoming shoots appeared on the short day plants once again, whilst vegetative shoots appeared on the full day plants. Both of these were removed as they appeared.

The principle object of the test was that the hormone previously accumulated in the leaves of the plant be transferred, by means of grafting, to a plant not possessing same (tops). In all, 14 experiments were made in grafting blossoming plants, there being 4 controls.

After the grafted tops had grown in new leaves began to appear on them. The leaves from one part of the grafted tops were stripped in both the experimentals and the controls.

For forty days after the operation all the plant tops were in no way distinguishable from each other, but beginning from July 29th fruit shoots began to appear on all the scions grafted to blossoming stock. Between August 8th and 17th all the scions were in blossom bar two which commenced blooming on August 25th and 29th. The scions grafted to vegetating stock did not bloom or form fruit shoots.

Figure clearly shows the marked changes undergone by scions grafted to blossoming stock.

During 40 days, the right-hand scion grafted to blossoming stock remained similar to that on the left, grafted to vegetating stock, but the gradual change arising under the effect of the hormone flowing from the stock resulted in the condition evidenced by the photograph.

This experiment shows that the blossom-forming hormone or florigen accumulated in the plant under the influence of a short day, will, following the grafting on such a plant of a vegetating shoot, pass via the grafting point together with nutrient substances and direct them for the formation of flowers and seed.

Towards the end of the experiments, on September 20th, fully matured seeds were gathered from all the scions grafted to blossoming stock. The control scions, i. e. those grafted to vegetating stock, remained in a vegetative condition till the end of the experiment and formed no fruit shoots.

As already mentioned, in part of the scions, both experimental and control, the newly appearing leaves were not removed. In these experimental scions blossoming commenced simultaneously with those in which the leaves were removed but the formation of racemes and full bloom was retarded until 4th—7th September. Moreover, parallel with the formation of blossoms and partial maturing of seed, vegetative shoots and new leaves again appeared.

It may be assumed that the leaves remaining on the scions exert some sort of retarding influence on the formation of flower and seed.

Comparing the scions without leaves and those with leaves on the test stock allows another solution to this question. In the first instance the scion receives a definite quantity of plastic substances and a definite quantity of hormone which direct the plastic substances for the formation of blossoms and seed. In such cases the reaction is sharply defined. In the second instance, the quantity of hormone passing from the stock remains the same, but to the quantity of constructive plastic substances passing from the stock is added a large quantity of plastic substances from the leaves remaining on the grafted scion. The regulative action of the hormone in such cases is therefore unable to embrace all the shoots and new, vegetative shoots appear parallel with the blossoming and maturing of fruit shoots.

Blossoming and Seed Formation in Scions Grafted to Stock Previously Subjected to a Short Day. (Photographed August 27th, 1936)

The experiments dealt with in this work once again confirm the presumption that blossoming plants represent a source of blossom-forming hormones, or florigen and can be utilised as stock for accelerating the blossoming and fruit-bearing both in not flowering annuals and in perennials.

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PHYTOPATHOLOGY

ON THE PHENOMENON OF MYCOPHAGY

By A. R. VERNER and V. F. ALTERGOT

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The fungus organism's lytic dissolution has been noted by a number of investigators ([1], [6], [11], [8]). These authors demonstrated the decomposition of mycelium and fungus spores in a culture of *Ustilago*, *Verticillium*, *Fusarium* and other fungi together with certain bacteria. The authors are inclined to look upon the decomposition as due to the depressing and lysing action of the bacteria, regarding the interrelation between fungus and bacterial organism as antagonistic. An analogous phenomenon of lysis, occurring without the second organism, as if spontaneously, was described by Dmitriev ([5]) for actinomyces.

In studying some problems of the physiology of fungi of the genus *Fusarium*, we frequently observed ([4]) the phenomenon of lysis in a pure culture; *Fusarium niveum* Smith, cultivated on rice, when transferred on to Waxman's agarized medium, frequently manifested a strong dissolution of the mycelium. Four or five days after planting, the growing colony became slimy and after 10 or 12 days it was hard to find undecomposed mycelium, either on the surface or in the substratum itself. Examination of the colony under the microscope revealed no contamination, which fact pointed to other causes for the dissolving of the fungus. While working with a culture not derived from a single spore and long not tested for purity, we considered it necessary to obtain single-spore strains, placing them under conditions acting unfavourably on the bacterial organism. A suspension of single-spore culture in the stage of abundant spore formation was heated for 10 to 15 minutes at 70° C and was spread out over the Waxman medium prepared in a 0.3 *n* solution of KCNS ([9]). The strains obtained under these conditions manifested a strong dissolution. It must, therefore, be considered that the spontaneous lysis noted by Dmitriev in actinomyces was not a rare case. This is confirmed by our own observations on the *Fusarium* species. Thus, lysis may take place without the antagonistic action of a stimulating agent.

The present paper is devoted to our investigation of the causes of spontaneous lysis in fungi of the genus *Fusarium*.

The morphology of the phenomenon of lysis in *Fusarium* in the presence of a second organism has been described by some of the authors mentioned above ([8], [11]). But non-antagonistic lysis is new in the literature, for which reason we describe it in detail.

1. Character of Lysis in the Colony. Single-spore lysing cultures were planted on the ordinary agarized and non-agarized media: Waxman's, must, Richard's, and certain special ones. In the course of the development of the cultures, we were able to note different characteristics of the lysis. In some cases, the colony, when just beginning to grow and before attaining a diameter of 1 cm, quickly became slimy, the mycelium disappeared from the surface of the medium, and the colony was converted into a pellicular structureless film, hardly distinguishable from the substratum. When this occurred, the colony's growth slowed down and stopped. In other cases, no such rapid onset of lysis was observed, the colony developed normally at first, until it reached a diameter of about 4 or 5 cm, after which lysis set in from its periphery, and spread to the centre, as was remarked by Khudjakov (11). A third type of lysis is that in which the colony grows normally up to its size limits and then, after 2 or 3 weeks, dissolution of parts of it sets in. It is characteristic that often smallish islands of normal mycelium, growing concentrically into daughter colonies, appear on the surface of a wholly or partially dissolved colony; this was also noted by Dmitriev (5) for actinomyces.

2. The Microscopic Picture of Lysis. A quick decomposition of the material is characteristic for pieces of a lysing colony when transferred to the microscope slide, although no change can be discerned macroscopically in a drop of water. It is only in rare cases that one is able to discover multicellular mycelium in such preparation under the microscope, this mycelium being distinguished by washed out edges of the hyphae; fragments of mycelium of indefinite size and shape, without internal content, piled up in a formless mass, are usually observed. The characteristic general background consists of thickly scattered particles of indefinite structure and of different sizes; the size of a particle is always less than the width of a hypha, and the smallest are barely distinguishable under the microscope. The comparatively great stability of the chlamydospores is worthy of note; often in what seems to be a wholly destroyed fungus mass, one finds intact chlamydospores, either free or with only smallish pieces of hyphae attached. The micro- and macrospores seem to be less stable and are encountered only in but slightly decomposed mycelium.

This difference in stability of the elements of the fungus may explain the formation of daughter colonies which we noted above and also the different results when making cultures from the lysing colonies; in some cases, a completely lysed colony proves to be sterile, in others it gives a culture. In the latter case, the growing colony either undergoes another lysis or else develops practically constant non-lysing forms—a phenomenon analogous to the rise of stable bacterial forms during bacteriography (7).

3. The Lysis of the Fungus in its Dependence on the Substratum. We frequently observed the picture of lysis that we have just described when we planted lysing and practically non-lysing strains of *Fus. niveum* on various agarized media. Our observations on growth and lysis are shown in Table 1.

Analysis of the table shows how inconstant is the lysing character of the fungus: strains that had shown themselves resistant to lysis, undergo the same on must-agar and Waxman's medium, while growing normally on Richard's medium. In the same way, lysing strains manifest a rapid and deep lysis on Waxman's medium and must-agar and no lysis on Richard's medium. The interdependence between the rate of growth and the onset

Table 1

Strains of *Fus. niveum* Smith	Medium	Beginning of microscopic growth after planting	Rate of growth	Beginning of lysis from time of planting	Character of colony's lysis	Secondary growth	Depth of colony's lysis
Strain III, non lysing	Must-agar	After 2 days	Moderate	No lysis	—	—	—
	Waxman's	» 2 »	Rapid	On 5th day	At edges	Present	Transfer positive
	Richard's	» 4 »	Slow		No lysis		—
Strain III(a), lysing	Must-agar	After 24 hours	Rapid	From beginning of growth	Whole colony	None	Transfer positive
	Waxman's	After 2 days	Rapid	Ditto	Ditto	»	Transfer positive
	Richard's	» 3 »	Slow		No lysis		—
Strain IV, non-lysing	Must-agar	» 3 »	Moderate	On 6th day	Weak at periphery	None	Transfer positive
	Waxman's	» 1 »	Rapid	On 5th day	At periphery	Present	Transfer positive
	Richard's	» 4 »	Slow		No lysis		—
Strain IV (a), lysing	Must-agar	» 1 »	Rapid	On 4th day	Rapid from periphery	None	Transfer negative
	Waxman's	» 1 »	Moderate	Ditto	Whole colony	»	»
	Richard's	» 3 »	Slow		Weak lysis		Transfer positive

of lysis is characteristic; accelerated growth goes hand in hand with increased lysis.

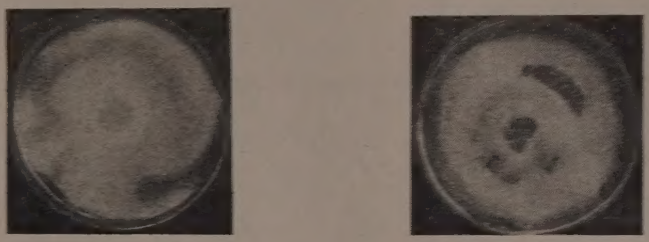
We may regard the phenomenon of lysis as the result of the upsetting, during the organism's reproduction, of the normal relation between the destructive and the formative processes ([3], [2]). As a result of the disturbance of this relation during accelerated growth, there seems to occur an excessive accumulation in the medium of the factor that causes lysis.

4. The Genesis of Lysing Principle. The remains of a deformed fungus mass were separated by filtering from a three-months lysing culture of *Fus. niveum* grown on Richard's medium. The mass that was filtered off was ground with sand in a mortar, water was added (1 : 5) and drained with a Buchner funnel. The slightly opalescent extract that was obtained, and also the filtrated substratum on which the fungus grew, were sterilized in two ways: one part was passed through a Seitz filter No. 3, the other was subjected to a repeated boiling for 15 to 20 minutes. Kept at room temperature, the preparations gave no signs of contamination. These preparations will henceforth be designated as follows: Mf—medium sterilized by filtration; Mt—medium sterilized by heat; Ef—extract from fungus mass sterilized by filtration; Et—extract from fungus mass sterilized by heat. In one series of experiments, 2 cm^3 of the preparations were introduced before planting in the melted Waxman's medium in Petri dishes; in the other series, the same quantity was introduced on to the surface of the medium in the form of separate drops after the colony had attained its

Table 2

Species of Fusarium	Character of lysis of colony at various periods of growth							
	Preparation introduced into the medium before planting					Preparation introduced on to the cultures		
	Age of culture in days				Microscopical picture of lysis on the 10th day	Number of days after introduction		Microscopical picture of lysis on the 9th day
Preparations	5	11	18	18		1	7	
F. niveum control	Normal colony covering whole dish					Colony normal		
Mf	No lysis diameter of mycel colonies twice greater than that of control	No lysis size of colonies not greater than that of control	First signs of lysis at periphery	Deepening lysis at periphery	Hits of my cellium having in definite contours accumulation	Dissolved patches of about 1.0 to 1.5 cm	Patches have increased in size to from 2 to 5 cm.	Chlamydospores visible no micro- and macrospores Abundant growth
Mf			Separated transparent patches	Non-lysing portions appearing as islands		Patches of about 1.5 cm in diameter	Patches from 2.5 to 3 cm in diameter	
Ef			No difference from control	First signs of lysis in middle	Microspores in groups of 5 to 10 in the field of vision	"	Half the colony has dissolved	
Ef			Clarification of separated patches	Non-lysing portions appearing as islands		"	"	
F. lini control	Normal colony covering whole dish					Colony normal		
Mf	No lysis diameter of colonies exceeds that of control 2 or 3 times	First signs of lysis Size of colonies somewhat greater than that of control.	Lysis of colony from periphery	Only in middle smallish islands of mycelium	Only chlamydospores visible against a background of bits of hyphae grading mass	Patch in the centre of colony, of about 3.0 cm	Has increased to 4 cm	Chlamydospores present; no mycelium, abundant germination Deeper decomposition than in case of *F. niveum*
Mf			Large transparent spots	Smallish islands of mycelium Whole colony transparent		Patch at the edge of about 2.5 cm	4 large patches	
Ef			Dissolved patches of about 1.0 cm	Two patches about 2 cm		"	"	
Ef			Transparent ring at edge of colony about 1.5 to 2 cm wide	Width of ring about 3.0 cm		Patch in the middle of about 1 to 1.5 cm	Colony more than half lysed	

maximum size. Cultures of fungus grown on the unchanged Waxman's medium served as controls. The experiments were conducted with non-lysing strains of *Fus. lini* Bolley* and *Fus. niveum*. The temperature was

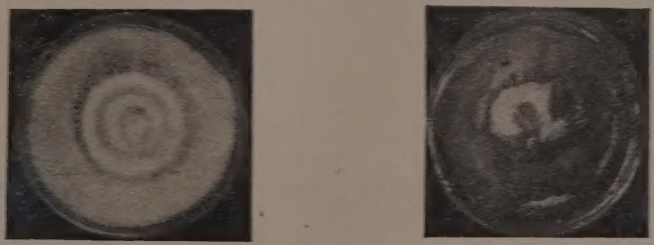


a *b*

Fig. 1.

kept at 27 to 28 C°. There were two of each variant. An experiment was carried out according to the same plan using test tubes instead of dishes; the results were identical in both cases. In Table 2 we describe only the cultures in the Petri dishes.

The data shown in the table point to the ability of the fungus to form a lysing principle; that principle accumulates in the substratum, where



a *b*

Fig. 2.

there occurs a lytic decomposition of the fungus, and it may be obtained from the remains of the disintegrated fungus mass. Lytic decomposition is to be seen in the experimental dishes not only for *F. niveum* (Fig. 1, *a*—control; Fig. 1, *b*—Et introduced) but also for the hitherto non-lysing species, *F. lini* (Fig. 2, *a*—control; Fig. 2, *b*—Mf introduced). The thermostability of the factor producing lysis forces itself on the attention.

We are, consequently, inclined to regard the processes connected with lysis as consisting of the irritating action of a non-vital principle on the organism which leads to lysis, and of lysis proper. The latter may be compared to the decomposition of the organism in bacteriophagy.

Looking upon this statement as a working scheme, we may consider the hitherto described phenomena of lysis in fungy as fundamentally differ-

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* This strain was obtained from A. I. Raillo.

ing from bacteriophagy in the sense used by D'Erella ([10], [3], [2]) and must regard them to be automycophagy.

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